THE AMATEUR'S BOOK

OF

WIRELESS CIRCUITS

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"WIRELESS WORLD AND RADIO REVIEW"

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FOREWORD

THE steady advance of wireless telegraphy and telephony brings with it a multiplicity of circuit principles and in this book an endeavour has been made to present to the experimenter those circuits which have become standard practice together with others designed or adapted to suit his specialised requirements.

The design of the circuits has been considered with a view to meeting the difficulties usually encountered when constructing experimental apparatus and it will be noticed that the circuits are all of an essentially practical nature, while the text which accompanies them has been drawn up from a practical standpoint. In most cases it will be found that the complete circuits given can be taken as they stand but it is quite a simple matter, of course, to embody principles shown in one circuit with those found in another.

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GENERAL CONSIDERATIONS
ON THE PROPERTIES AND OPERATION OF CIRCUITS

Considerations of cost, convenience of accumulator charging and the like are not discussed here, the technical merits of the various circuit arrangements, only, being dealt with

To guide the beginner in the selection of circuits which involve no great difficulty in making up in instrument form asterisks have been added to certain of the identification numbers. Circuits thus marked represent well tried practice and give easy manipulation.

CRYSTAL RECEIVERS

FOR reception over short distances the crystal detector is satisfactory. The simple arrangements shown in the early diagrams in this book consist merely of an inductance coil connected between the aerial and the earth and bridged by the detector and telephones.

Tuning Inductances for Crystal Receivers.—The tuning circuit may be rendered continuously variable by a sliding contact on the turns of the inductance or, alternatively, an inductance of the variometer type may be employed. Another method, though not generally used, is to tune by means of a copper plate arranged to slide over the inductance which latter may take the form of a basket or slab coil. Again, the circuit may be tuned by a pair of basket coils sliding one over the other, although this, as with the variometer and damping plate methods, produces only a limited wavelength change and tuning is restricted to a narrow band of wavelengths. Another method of tuning is to vary the number of turns of wire in the inductance by means of tapping leads brought to the contacts of a multi-stud switch and by making use of two such switches the turns can be tapped out from either end of the coil, one switch tapping out, say, every ten turns whilst the other, fitted with ten stud contacts, taps out single turns so that any exact number of turns may be included in circuit.

The size of the coil will depend upon the wavelengths on which the receiver is to be used. Single layer windings are most suitable for wavelengths up to about 1,000 metres although they may be employed almost up to any wavelength but become rather cumbersome on wavelengths over 5,000 metres. For telephony reception on wavelengths of the order of 400 metres an inductance consisting of 110 turns of No. 26 double cotton covered wire on a former $2\frac{1}{2}''$ in diameter will give the required tuning.

Series Aerial Tuning Condenser.—For reception on wavelengths below 800 metres signal strength is usually improved when a small

value condenser (about 0·0003 mfds.) is connected in the lead between the aerial and the inductance. This series connected condenser when introduced shortens the wavelength to which the circuit will respond and more turns on the inductance coil must be added to compensate for this reduction. The few extra turns thus included in the tuning circuit produces a greater potential for operating the crystal with an improvement in signal strength, whilst the series condenser has the effect of sharpening the tuning and reducing interference.

The series tuning condenser should not be connected on the earth side of the inductance for although influencing the circuit with regard to shortening the wavelength it is in effect, itself, short circuited. When any of the apparatus in the tuning or detector circuit is handled, such as the hand placed upon the tuning coil or detector for the purpose of adjustment or the telephones placed upon the head, it will readily be seen that a leak is set up across the condenser.

By the use of a variable tuning condenser it is possible to employ tuning inductances which are tapped in steps or are interchangeable and of the plug-in type.

Series-Parallel Condenser Switching.—As shown in many of the circuits, the aerial tuning condenser may be connected either across or in series with the inductance by the use of a double pole two position switch. For a long range crystal receiver this switch is a necessity. On wavelengths over 800 metres the condenser should not be used in series, for one must remember that a series condenser increases the resistance of the tuning circuit and cuts down the amplitude of the oscillations which are set up by the incoming signal. Although this resistance is inappreciable on short wavelengths it increases as the wavelength increases whilst the extra turns of inductance used with the series condenser as compared with the parallel arrangement also produce undesirable resistance effects.

A point that should not be overlooked when wiring up an aerial tuning circuit which includes a variable condenser is the advisability to connect the terminal of the condenser, which is joined to the moving plates, to the earth side of the circuit. This precaution is necessary because the hand may partially earth the moving plates when the condenser is adjusted.

Loose Coupling.—Loose coupled receiving tuners consisting of a complete aerial tuning circuit and a separate closed tuned circuit, the latter comprising an inductance bridged with a condenser, are generally adopted with crystal receivers when it is desired to eliminate interference and limit the band of wavelengths to which the set will respond. The energy is transferred from the aerial to the closed circuit by magnetic coupling between the aerial and closed circuit inductances and the further these inductances are placed apart the narrower will be the receiving band of wavelengths. As the distance between these two coils is increased the damping in both circuits is reduced, or, in other words, the received oscillations may build up to greater amplitude as the spacing between the coils increases, though, of course, the amount of energy transferred across the coils is lessened.

Variable coupling between two inductances may be arranged in a variety of ways among which might be mentioned, sliding one cylindrical coil in or out of another, rotating a cylindrical coil mounted inside a larger one, swinging a flat coil across a similar coil, lifting a flat coil away from another or pivoting it and swinging it away very

much like the opening of a book. When rotating a cylindrical coil inside another it is as well to remember that the maximum dimensions of this moving coil are obtained when its length is equal to its diameter.

Semi-aperiodic Aerial Circuits.—So called semi-aperiodic aerial tuning circuits are frequently made use of with advantage, the arrangement consisting of aerial and closed circuit inductances, more or less tightly coupled and with no provision for varying the extent of coupling. In making a receiving tuner of this sort the two windings should not lie in contact with one another and some advantage may be gained by either winding the two inductances end on on the same former or by winding on separate formers and fixing one coil inside the other. With the moderately tight coupling thus produced it will be found that convenient tuning is obtained with considerably fewer turns on the aerial inductance than on the closed circuit inductance and that the tuning condenser on the closed circuit tunes both inductances simultaneously. It may be however an advantage to provide a few tapping points on the aerial coil.

Change-over Switch.—Returning again to variable loose coupling, it is very useful to fit a change-over switch for introducing the closed circuit as required. Such a switch has been known for many years as the " tune and stand - by switch " inasmuch as when the closed circuit is out of action the receiver is more or less flatly tuned and is ready to receive over a limited band of wavelengths without making continual searching adjustments, whilst when communication is established the closed circuit is brought into operation in order to eliminate interference. The utility of this arrangement is, of course, still applicable for the reception of spark or moderately damped transmissions whilst with continuous wave signals and valve receivers variable loose coupling is particularly useful for critically adjusting self oscillation by altering the damping in the high frequency circuits of the receiver. The switch employed should preferably be fitted with three arms in order to sever one lead of the closed circuit condenser from its inductance when the closed circuit is not in use in order to prevent it having a tuning effect upon the aerial circuit. This emphasises the point that when the tuning of one of two coupled circuits is altered the tuning of the other changes also.

Common Types of Crystals.—A few words on the respective merits of crystals may be helpful. Possibly the most stable crystal is carborundum used in conjunction with a steel plate. This detector is easily set and is not susceptible, to any great extent, to electrical or mechanical influence. To operate it successfully a potential should be applied from a small dry cell battery and regulated by means of a potentiometer or, alternatively, a suitable potential may be developed across its contacts by feeding the battery current through a high resistance of several thousands of ohms. This latter method is economical with battery current as compared with the potentiometer arrangement, but necessitates the use of a variable high resistance, a component almost impossible to produce satisfactorily. Alternatively, the specimens of carborundum must be so well chosen that when crystal replacements are made a fixed resistance will be suitable with any specimen. Carborundum, however, is not of uniform structure and various pieces are usually different in their detecting properties.

Galena in many forms is extensively used as a detector, particularly in simple sets where the fitting of potentiometer and battery is

undesirable. This type of crystal is marketed under many names, each variety having been treated by some special process or being a form of lead sulphide with a semicrystalline structure.

Silicon is a very satisfactory crystal and gives best results as a rule without the use of a potentiometer and battery.

The various galena crystals and silicon are used with a light wire contact, the wire being of iron, copper, brass or gold, the latter being adopted owing to its non-oxidising properties.

The perikon detector consists of a contact between two natural crystals one of which is usually zincite and the other bornite or copper pyrites.

Circuits showing electrolytic and magnetic detectors do not appear in this book as they are not used very extensively at the present time because the former, although being sensitive, is often messy and difficult to manipulate, while the latter is comparatively insensitive.

Telephone Condenser.—It is customary to bridge the telephone receivers of a crystal set with a small condenser in order that the interrupted rectified currents derived from each oscillation train may have an accumulative effect when fed to the telephones. In practice the fitting of this condenser is not essential as the windings of the telephones and telephone cords possess appreciable capacity. The use of the telephone condenser is however recommended and should have a valve of 0·001 mfds.

SINGLE VALVE SETS

When a single valve is used the circuit should comprise the usual reaction arrangement in which the inductance of the tuned aerial circuit is connected across the grid and the filament negative of the valve and in the plate circuit are the telephone receivers, reaction coil and high tension battery. Several circuits of this type are given in both schematic and practical forms.

Concerning Construction.—The aerial tuning inductance may be of a form already described while the reaction coil is mounted so as to provide a variable coupling with the aerial circuit.

There is considerable latitude as to the number of turns of wire required for the reaction coil and a given reaction winding is suitable for use in conjunction with an aerial circuit which may be tuned over quite a wide wavelength range. For instance, a reaction coil $1\frac{3}{4}''$ in diameter and wound with 70 turns of No. 28 double silk covered wire may be used with a tuner covering a wave range of 200 to 800 metres The greater the damping in the reaction coil winding the wider is the wave range over which it will operate. The damping is increased by both resistance and capacity and thus the reaction winding may consist of fine enamel covered wire (No. 36 S.W.G.) When the reaction coil is pivoted inside an aerial or other inductance, it is advisable to make provision for it to move through 180° so that the magnetic field of this coil can be completely reversed. If, however, swinging coils of the plug-in type are adopted it is necessary to ascertain in which direction connections are made in order to produce suitable oscillating effects in the circuit. It might be mentioned here that when the reaction coil is tuned with a variable condenser oscillating effects can be obtained irrespective of the direction of the current through the winding and that quite loose reaction coupling is all that

is usually required. In the case of an oscillating receiver such care need not be taken with regard to keeping the resistance of the aerial inductance to a minimum, as is the case with a crystal detecting of non-oscillating valve set. The usual precautions must be taken particularly on the shorter wavelengths, to keep the self-capacity of the windings as low as possible by suitably spacing the turns. It must not be overlooked that the insulating material between the turns of an inductance is the dielectric of the condenser which is represented by its self-capacity. Dielectric losses occur in this insulation and these losses increase as the wavelength decreases. Thus inductances with air spaced turns and merely supported by insulating strips are ideal for short wave work.

Reaction and Oscillation Control.—A critical degree of self-oscillation can be secured by using a tuned variometer plate circuit instead of a reaction coil. Good signal strength may be obtained by this method together with satisfactory oscillation control although in the aerial tuning circuit a suitable ratio of inductance to capacity must be employed. It is common practice in receivers making use of the variometer tuned plate circuit to tune the aerial, also, with a variometer and in designing such a set the aerial variometer is made of a size permitting of the introduction of a series aerial condenser in order to stimulate oscillation in the circuit.

Greater signal strength can usually be obtained on the shorter wavelengths, that is wavelengths up to 700 metres, by connecting the aerial tuning condenser in series with the inductance in the aerial circuit. It will be found, however, that self-oscillation occurs much more readily and erratically with the series aerial tuning condenser than when it is used in parallel across the inductance.

Reference might be made to the interference caused by oscillating receiving sets, and within the author's experience it has been found possible to communicate over a distance of eight miles making use of an oscillating receiving set with an ordinary " R " type valve and a plate voltage from the H.T. battery of only 40. It is difficult to suggest what should be done to stop this form of interference especially as maximum range is usually obtained with a suitable degree of self-oscillation and bearing in mind also, that many standard receivers used by those having no technical interests were designed by the manufacturers to oscillate. A rough test for oscillation in a receiving set is to notice whether a loud click is heard when the aerial terminal is touched with the finger. The howling noise so often heard in the telephones when the reaction coupling is tightened up indicates oscillation of course, but the extent of high frequency oscillation in the aerial circuit may be considerably less in this condition than when the receiver has a high degree of sensitiveness usually so sought after.

An annoying property of a valve receiver is to find that oscillation occurs with a certain degree of reaction coupling and when an attempt is made to reduce it that the oscillation ceases abruptly and to restore it again the coupling has to be increased to a position considerably tighter than that where oscillation stopped. This effect is known as " overlap " and is generally due to the use of an unsuitable grid condenser or leak and the replacement of these by others of more suitable value cures the trouble. A little positive bias on the grid of the valve, such as may be obtained by connecting the grid leak to the

positive of the filament battery instead of the other side of the grid condenser usually overcomes the difficulty of overlap but signal strength is to some extent sacrificed and distortion possibly introduced when receiving telephony. One should bear in mind that reaction coupling in any circuit should be kept to a minimum and that self-oscillation in a receiver is almost certain to introduce some degree of distortion.

Grid Condenser and Leak.—The grid condenser is customarily taken as having a value of 0·0002 mfds. when used on wavelengths up to 600 metres and 0·0003 mfds. on longer wavelengths. Compromising between these two values many experimenters employ one value 0·00025 mfds.

The value of the grid leak in an oscillating single valve set may, in general, be 2 megohms, and if any variation from this value is required, tests can be made by substituting leaks of the clip-in type.

Filament Current Control.—The filament resistance is usually connected in the negative filament lead. The potential of the grid is largely controlled by the lead in which the filament resistance is connected and when joined in the negative, additional negative bias is applied to the grid as a result. This is generally required in oscillating and low frequency amplifying circuits. When connected in the negative lead the grid potential will be varied with adjustments of the filament resistance. If connected in the positive lead and the earth end of the inductance is joined to the negative of the battery no change will result in the grid potential when the filament current is varied. Suitable resistance values are referred to in the circuit pages.

By-pass Condenser.—In order that high frequency currents may be passed *via* the telephones to the reaction coil it is necessary to bridge them with a condenser and a usual value is 0·001 mfds. In the case of a single valve receiver this condenser can be made to bridge the high tension battery also, so that the oscillating currents will not be damped down by the resistance of the battery.

Battery Connections.—There is no objection in the single valve circuit to connecting the H.T. battery on the reaction coil side of the telephone receivers provided that this battery is not required to operate other apparatus and it is not of the H.T. accumulator pattern which usually requires to have one of its poles earthed for charging purposes.

In the circuits throughout this book it will be observed that the negative of the H.T. battery is connected to the negative of the filament battery. This is essential if an H.T. accumulator is employed, and in any case, it is convenient to have one terminal of the H.T. battery at earth potential. Moreover, in experimental circuits in which only temporary connections have been made there is a danger of burning out the valve filament should the L.T. be switched off and a lead in one of the valve plate circuits make contact with an earthed point.

Telephone Connections.—Telephone receivers are frequently connected directly in the plate lead and no serious harm is likely to occur in the case of a single valve receiver where the constant plate current does not exceed three or four milliamperes. When the telephone terminals are marked + and − it is advisable to correctly connect them in the circuit. Other methods of connecting the telephones by means of transformers and chokes are described later.

HIGH FREQUENCY AMPLIFIERS

Amplification at high frequency is introduced into receiving sets for the purpose of increasing the receiving range. At short range or when receiving from a powerful transmitting station very little is gained by H.F. amplification but when signals are weak, or fail by reason of transmitter and receiver working at extreme range then suitable H.F. amplifying circuits must be added.

High frequency amplification may usually be effected by one of four methods termed, tuned anode, tuned transformer, semi-aperiodic transformer and resistance-capacity.

Tuned Anode Circuits.—The tuned anode method consists of connecting into the plate lead a tuned circuit comprising an inductance bridged with a tuning condenser and is particularly applicable to amplification on wavelengths between 180 and 1,500 metres. It is useful on even shorter wavelengths to produce and control oscillation while on wavelengths greater than those mentioned it functions well but is not always employed as it can be replaced by partially tuned or resistance-capacity coupling which give easier manipulation.

The inductance in the tuned anode circuit may be a tapped single layer or plug-in coil and to cover a wavelength range of 200 to 600 metres it should consist of 90 turns of No. 26 D.C.C. on a $2\frac{1}{4}''$ former, whilst tappings may commence at about the 30th turn. With plug-in coils those usually known as 35, 50 and 75 are needed. When a switch is employed to vary the number of turns in a tuned anode coil it may be arranged to short circuit the turns not in use or, better still, a switch blade can be used which always bridges two studs and the spare end of the coil left open. It is as well to try out these methods as their merits will depend upon other factors in the receiving circuit.

The tuning condenser should not exceed a maximum value of 0·0003 mfds., and 0·0002 mfds. is generally recommended. The condenser spindle should invariably be connected on the H.T. battery end of the inductance.

The grid of the high frequency amplifying valve usually requires a negative potential. This is obtained by connecting the end of the aerial or closed circuit to the negative of the battery with the filament resistance in either the positive or negative lead, though the additional negative bias obtained by the latter arrangement may cause excessive oscillation.

Controlling oscillation in a tuned anode high frequency amplifier sometimes presents difficulty, and critical adjustment may be given by a reaction coil joined in the plate circuit of the detector valve and variably coupled to the tuned anode inductance connected in a direction to damp down oscillation. In this instance an additional reaction coil should be provided in the aerial circuit to stimulate oscillation, the two reaction inductances being connected in series or one reaction coil may be set up in the centre of a three-coil holder with aerial and tuned anode inductances on either side. Other methods consist of bridging the tuned anode circuit with a resistance having a value between 0·1 and 0·5 megohms (1 megohm = 1,000,000 ohms), fitting a potentiometer to produce damping by introducing more grid current and the neutrodyne arrangement., Oscillation may also be controlled in the tuned anode circuit by connecting in series with the inductance a resistance having a value of one or two thousand ohms. Alterna-

tively, this resistance may be joined in the lead between the H.T. battery and the tuned circuit. The damping of a tuned anode circuit for the purpose of producing stable working, and flattening tuning and self-oscillation adjustments, may be obtained by increasing either the resistance or capacity of the tuned circuit.

The use of more than one tuned anode circuit is not recommended unless one of the arrangements just mentioned is adopted and the amplification per stage then being less it is doubtful if very much is gained by the use of the additional apparatus. It is questionable whether any attempt to simultaneously tune two self-oscillating high frequency amplifiers would meet with success.

Tuned Transformer H.F. Coupling.—In the tuned transformer method of high frequency amplification, primary and secondary windings are tightly coupled and simultaneously tuned with a variable condenser which, for wavelengths from 200 to 1,500 metres, should have a maximum value not exceeding 0·0002 mfds. Various types of transformers have become standardised and in particular might be mentioned the pattern in which valve socket mounting is employed for interchangeability. The primary and secondary windings should not be run on together but either wound in separate grooves or insulated from one another. The two windings are put on in the same direction, the beginning end of the primary and the finishing end of the secondary being taken to the plate and grid respectively.

Another form of transformer, and one specially recommended, comprises primary and secondary wound upon cardboard formers, or ebonite strip supported air spaced windings placed one inside the other. The tuning condenser may be connected across either the primary or the secondary and with this method of construction it is permissible to include more turns on the secondary than on the primary with the object of producing a step-up of potential. For wavelengths of 200 metres the primary may consist of 10 turns of No. 24 D.C C. on a 3″ cardboard former and the secondary 34 turns on a 2½″ former, the secondary being placed inside the primary. For an optimum wavelength of 400 metres the primary may have 28 turns on a 3″ former and the secondary 60 turns on a 2½″ former. The wavelength range of these transformers will be largely influenced by the relative position of the coils which will need to be wound in opposite directions and adjusted to produce the desired wavelength range. Grid and plate connections are at the same end.

Basket coils make excellent H.F. transformers and a primary of 40 turns of No. 28 D.S.C. wire with a core diameter of 1″ and a secondary with 50 turns of the same wire will tune from 280 to 550 metres when the primary is bridged with a 0·00025 mfds variable condenser. The spacing between the two coils requires critical adjustment and will be about 3/16″. The coils should be placed so that the windings run in opposite directions and the outside ends taken to grid and plate.

High frequency amplifiers may be built comprising a number of stages in which no provision is made for tuning other than that the inductances are adjusted to an optimum wavelength. It will be readily realised that poor amplification will result if all of the transformers are not exactly equal, for one having a different wavelength range would not pass signals on which the other transformers efficiently amplify. A certain degree of damping is essential with multi-stage

amplifiers of this type in order to broaden the tuning range and is effected by winding .the transformers with fine wire, such as No. 44 D.S.C. or even using resistance wire say No. 46 " Eureka " which is mechanically stronger than the fine copper wire. Damping may also be produced by grid current obtained when controlling the potentials of the grids by grouping the filament ends of the secondary windings and connecting them to the slider of a potentiometer which is joined across the L.T. battery.

Some degree of reaction is useful with this form of amplifier and can be set up by connecting the grid of the first valve to the plate of the second or fourth, or to the grid of the third, through a small variable condenser having a maximum capacity of about 0·00005 mfds.

Resistance-capacity H.F. Coupling.—For wavelengths over 1,500 metres resistance-capacity coupling gives good results though the degree of amplification obtainable does not equal that given by the tuned arrangements. Yet, inasmuch as no tuning is required this method recommends itself and a number of stages of resistance-capacity coupled high frequency amplifiers can be set up. The resistances should have a value of about 100,000 ohms and must be capable of passing the required plate current of several milliamperes without deterioration.

Additional H.T. potential is, of course, required with resistance amplification owing to the voltage drop produced across the resistances.

With telephony on wavelengths over 1,500 metres resistance amplification may be specially recommended as the amplifying circuits are not self-oscillatory which, in itself, will minimise distortion, while the extra H.T. voltage required will suit the low frequency amplifiers these also being resistance coupled. With such a set it may only be necessary to tune the aerial circuit.

Detection after H.F. Amplification.—Reference should be made to the detector valve which follows the high frequency amplifier. With most valves working on a normal H T. potential it is necessary to connect the grid leak of the detector valve to the L.T. + to obtain rectification and this should be adhered to even when a reaction coil is in the detector valve plate circuit.

Where accumulating charging is a difficulty and to economise in filament current a crystal is sometimes used for rectification after a high frequency valve amplifier. Although used, it is not good practice to connect a crystal of the galena type and telephones across the tuned anode coil. The crystal is altogether too susceptible to applied direct current voltages to be connected in such a circuit, whilst the crystal and telephones are of comparatively such low resistance that serious damping is produced in the tuned anode circuit and as a result tuning rendered extremely flat and amplification reduced. To overcome these defects the use of a stable carborundum crystal, preferably with potentiometer, is advised, and instead of connecting it across the whole inductance and thus flattening the tuning only a portion of the turns should be utilised. By suitably coupling the tuned anode coil to the aerial or closed circuit the effects of damping may be reduced.

The most satisfactory scheme for crystal rectification is to connect crystal and telephones across the secondary of a tuned high frequency transformer so that the crystal is not affected by continuous plate current as is the case when joined to a tuned anode coil. The primary

of this transformer for a mean wavelength of 400 metres may consist of 70 turns of No. 26 D.C.C. on a 2½″ former and the secondary 50 turns of No. 28 D.S.C. on a 3″ former. It will be appreciated that a potential step-up is not aimed at, the object being to avoid too much damping of the oscillations in the tuned primary coil. Some 20 turns of the primary coil might, with advantage, be wound on a separate former and coupled to the aerial or closed circuit inductance.

Other H.F. Amplifiers.—There are many elaborated systems of high frequency amplification comprising series and parallel resonance circuits, and in which the anode current is fed through a suitable high frequency choke. These are not sufficiently standardised to be referred to here though practical data is given in the circuit pages. These circuits only interest the more advanced experimenters who are in a position to judge their merits and applications.

Switching H.F. Amplifying Circuits.—Methods are shown for switching high frequency amplifiers in and out of circuit. These can quite safely be put into practice provided the user employs low capacity switches having metal parts of small surface area with spaced connectors and adopts spaced stiff wiring for joining up.

The first consideration in the disposition of the parts on the receiver panel is not necessarily symmetry but an arrangement that will result in efficient wiring. The merit of a good design is one in which a pleasing appearance is obtained with easy manipulation and most important, a good wiring layout.

LOW FREQUENCY AMPLIFIERS

Amplification at low frequency, after detection has been carried out by means of a crystal or valve, is usually adopted when it is desired to operate a loud speaker. A single valve note magnifier does, in fact, slightly increase the range of reception though it is a good working rule that amplification at high frequency increases the range, while amplification at low frequency merely increases the strength of signals already discernible.

Filament Connections.—To introduce a low frequency amplifier it is only necessary to remove the telephones or telephone transformer from the plate lead of the detector valve and substitute the primary winding of an intervalve transformer, the secondary leads of which are taken to the negative side of the filament heating battery and the grid of another valve. The additional valve is operated from the same high and low tension battery supply as the detector and high frequency valves and the telephones are reintroduced between the valve plate and the positive terminal of the H.T. battery. This note magnifying valve should have its filament resistance connected in the negative battery lead, for by doing so the grid is given a little extra negative potential. This is done as it is necessary to operate a low frequency valve entirely on the straight sloping part of its characteristic curve in order to avoid distortion and it becomes necessary to make sure that the grid is given the requisite negative bias. With the resistance connected in the negative filament lead, the potential of the grid is altered when changes are made in the setting of the resistance and thus, when adjusting the filament resistance to give the best results one is not necessarily producing the required filament brightness but the most suitable grid potential. This difficulty

may be remedied by transferring the filament resistance to the positive lead and making up for the negative bias thus lost by introducing one or two small dry cells.

Power Amplifiers.—A second note magnifying circuit can be added in a like manner to the first by again substituting an intervalve transformer in the place of the telephones. It is not generally necessary to employ more than two stages of transformer coupled low frequency amplification and three stages should be the maximum. Two note magnifiers arranged as power amplifiers will produce as much amplification as is ever likely to be required. By power amplification is meant the use of specially designed valves and higher plate potentials accompanied by the insertion of a suitable number of cells in the valve grid circuits.

Intervalve Transformers.—It is difficult to give definite data concerning the design of intervalve transformers and one can only define a few requirements. For the first stage of low frequency amplification the transformer may have a ratio as high as 4 to 1 produced, not by limiting the number of primary turns, but by winding on ample secondary turns. Experience shows that this transformer should consist of about 30,000 or even more total turns and that attempts should be made in the construction to limit, to some extent, the self-capacity of the windings. Details concerning the arrangement of the core, such as its dimensions, whether or not it should be open or closed, and the permeability of the iron used, cannot be specified though many designs at present in use are quite satisfactory.

The subsequent stages in a power amplifier may be coupled with transformers of lower ratio, and ratios between $2\frac{1}{2}$ to 1 and 1 to 1 are satisfactory in use. The primary may be required to pass comparatively considerable current and the wire employed is usually No. 42 to 46 S.W.G. The experimenter making his own high ratio transformer and using No. 46 S.S.C. for both windings, which, by the way, is about the finest gauge· that can be safely handled without elaborate winding apparatus, may use about 5 ounces put into a winding space of $1\frac{5}{8}''$ diameter by $1\frac{7}{8}''$ long with a $7/16''$ closed core. A power transformer may be made up with a primary of 3 ounces of No. 42 S.S.C. and a secondary of 3 ounces of No. 44 S.S C built into a winding space of $1\frac{7}{8}''$ diameter by $2\frac{1}{2}''$ long the core being $\frac{1}{2}''$ in diameter. The windings should of course match the impedance of the valve.

Reducing Distortion.—However transformers are built it will be found that they pass certain note frequencies better than others and that uneven amplification is bound to result, though perhaps not to a serious extent. The resultant distortion may be minimised by shunting the transformer secondaries with high resistances, say of the order of 0·5 megohms and leak resistances of the usual clip-in type can easily be fitted to the transformers. This method of loading transformers to remove resonant note frequencies, does, to some extent, reduce amplification.

Choke L.F. Coupling.—Another method of low frequency coupling consists of feeding the plate current through an iron core choke coil, and passing on the potentials set up across this coil to the grid of the next valve or to the telephone circuit through a condenser. The grid potentials of note magnifiers connected on this principle are controlled by means of leak resistances. This type of amplification is only of experimental interest for it is not possible to obtain a potential step-up

between the valves as is the case with the transformer, whilst it has all the disadvantages of iron core low frequency coupling devices.

Resistance L.F. Coupling.—By substituting resistances for the chokes in the circuit just referred to another system of low frequency amplification is produced known as resistance-capacity coupling. Here, again, the degree of amplification is less than with the transformer method and under the best conditions can never exceed the amplification factor of the valve but it possesses the great advantage that all the apparatus used in the circuit including resistances, condensers and leaks operate almost identically over the entire band of note frequencies. Remarkable purity of amplification is obtained by this method though it may be necessary to introduce an extra stage of amplification to produce given signal strength.

Push-pull Amplifiers.—An arrangement known as a " push-pull " circuit and intended to give full wave amplification is frequently found in American apparatus. It employs two valves in each amplifying stage and can be recommended to be worthy of the attention of the experimenter.

Switching in L.F. Amplifying Circuits.—There are several methods of switching note magnifiers in and out of circuit and diagrams are shown in which (1) a lead is attached to the plate of the last valve and is transferred by switches or break-jacks to the plates of earlier valves, while the filament circuits of valves not in use are broken, (2) switching of transformer grid connections and breaking filament circuits of valves not in use and whose grids are still on the circuit and (3) building the note magnifiers as individual units fitted with plugs and sockets and plugging them in in succession as required.

Wiring L.F. Circuits.—Special precautions need not be taken as regards capacities introduced by switches and wiring so long as good insulation is maintained. The wiring of note magnifiers may, in fact, be complicated and many of the leads can, if necessary, be bunched together. The leads of an amplifier which is fitted with switches may be of insulated wire wrapped with strips of tinfoil and, where necessary, tied together to form a cable.

DUAL AMPLIFIERS

It is readily apparent that the full output of a valve is not made use of when it is functioning as a high frequency amplifier. This does not mean that it is not necessarily producing maximum amplification but that of the available plate current only a small amount is utilised in the form of fluctuating currents by the incoming signals. To put the valve to further use many circuits have been devised for the purpose of causing it to operate simultaneously as a high and low frequency amplifier. The process consists of connecting the valve in any standard circuit in which it will function as a high frequency amplifier and after rectification by valve or crystal to feed back the signals in to the grid circuit of the high frequency valve. The signals thus amplified at low frequency are heard in the telephones which are connected between the positive terminal of the high tension battery and the high frequency amplifying circuit. A typical dual receiver might thus consist of a tuned aerial circuit with the usual connection from the aerial side of the circuit to the grid of the valve. The valve plate circuit may include a tuned anode with crystal detector and

intervalve transformer, with the transformer secondary connected back into the earth side of the valve grid circuit and bridged with a small condenser so that the high frequency oscillations already taking place there are not interrupted by the inductive transformer winding. Telephones are connected in the H.T. lead as already explained and must be bridged with a condenser in order to pass the high frequency currents which are to take place in the tuned anode circuit.

Points in the Operation of Dual Circuits.—This straightforward circuit has many defects. Firstly, crystal detection in a tuned anode circuit considerably broadens the tuning in that circuit and takes away any tendency it may have to self-oscillate. Secondly, it is not recommended to connect a sensitive crystal in a valve plate circuit unless a type is used, such as carborundum, which is quite staple and operates in conjunction with a battery and potentiometer. Again, the high resistance secondary of the intervalve transformer will be practically short circuited unless the precaution is taken of joining the earth lead to the minus of the L.T. battery instead of on the aerial tuning inductance side of the transformer. The reader is referred to Circuit No. H.B. 75 where these points can be followed and it will be seen that if one assumes that the accumulator battery is almost an earthed point in a receiving set and the lower end of the inductance were to be earthed also, that little or no potential could be developed in the secondary of the intervalve transformer. The greatest difficulty of all in a dual circuit is due to the fact that the signals fed back into the grid circuit fluctuate its potential over a very wide range, while the incoming oscillations being of much smaller amplitude are merely passed as a ripple at high frequency superimposed on the low frequency pulsations. The efficiency of the valve may thus be impaired as a high frequency amplifier. In practice it is found that a straightforward dual receiver may possess some merit over a non-dualled arrangement but it must not be thought that the full high frequency amplifying properties of the circuit are maintained. Agreeing that low frequency amplification does not appreciably increase the range of a receiver, then receiving distance will be reduced when a high frequency amplifying circuit is converted into a dual amplifier. On the other hand, signals of moderate strength on the high frequency circuit will come in considerably stronger on the dual, in addition to which some degree of high frequency amplification is obtained and, in this respect, a dual circuit should be superior to one in which the detector is connected across the aerial circuit and the valve employed as a simple note magnifier. These observations on the operation of dual circuits apply to reception on wavelengths between 300 and 600 metres. On shorter wavelengths dual amplification is not used owing to the capacity leakage. Conversely on wavelengths over 1,500 or better still 2,000 metres the setting up of efficient dual arrangements is simplified.

When a crystal is employed as a detector it is advisable to couple the tuned anode coil with the aerial or closed circuit for unless this is done reception may be very poor in view of the damping produced by the comparatively low resistance crystal circuit. Another advantage is gained by doing this which may support a theory on the operation of the dual circuit. The coupled aerial and tuned anode inductances will set up oscillations on about the wavelength of the

incoming signal and the low frequency currents fed back into the grid circuit will modulate these oscillations in very much the same manner as a grid modulated transmitter.

By using a high frequency transformer instead of a tuned anode coil and slightly spacing the windings to produce moderately loose coupling it is possible to limit the damping set up in the tuned high frequency circuit and in addition the crystal is no longer in contact with the high tension battery.

" Series " and " Parallel " Dual Circuits.—It will be seen from the diagrams that there are essentially two systems for dualling circuits. The arrangement referred to on page 80 might be termed " series dual " inasmuch as the low frequency and high frequency circuits in the grid lead of the valve which is dualled are series connected. The other class of circuit might be termed " parallel dual " and in this case the secondary of the feed back transformer is connected across the tuning circuit. Here, provision must be made to prevent the tuning inductance short circuiting the transformer secondary and this is effected by linking them together with a small condenser, say one having a capacity not greater than 0·0002 mfds. which will offer very high reactance to currents at note frequency and yet will readily pass the high frequency currents through to the grid (see Circuit H.B. 79). Moreover, the capacity of the transformer secondary would act as a leak to the high frequency currents and to prevent this an effective high frequency choke coil having a low self-capacity is connected with it.

Designing Dual Circuits.—The scope in the design of dual circuits is almost unlimited and all one has to do is to rig up the required number of stages of high frequency amplification, rectify with a detector valve or crystal and feed back the signals by the series or parallel method into the grid circuit of either the first, second or other high frequency amplifier and connect the telephones or loud speaker either in the H.T. lead of that valve or a subsequent one which must be also fitted with the necessary low frequency couplings. Hence a typical circuit might consist of one high frequency amplifier followed by a second high frequency stage with valve detector. The signals might be passed back to the second H F. valve so that at least one H.F. circuit stands alone and functions efficiently. The telephones would be bridged with a condenser and connected in series with the tuned anode circuit of the second valve or an intervalve transformer might be inserted and followed by an independent stage of low frequency amplification. A vast variety of combinations is possible.

TRANSMITTING CIRCUITS

There is no need in this preliminary to deal with the various forms of oscillating circuits employed for transmitting purposes as they will be found under their respective titles in the pages devoted to circuits of this class. Some practical data and guidance in the interpretation of these circuits may be helpful.

Building a Transmitting Inductance.—Dealing first with a transmitting inductance such as is employed in the Hartley, Colpitts or reversed feed-back arrangements where it is necessary to make a number of connections on to a single coil, it is worth while building this with copper strip. For transmitters using between 10 and 200 watts a convenient sized strip is 3/8″ × No. 26 S.W.G. though there is con-

siderable latitude in the dimensions of the conductor used. Soft copper strip may be wound edgewise into a helix consisting of 40 to 50 turns about 8″ in diameter. In this inductance the first 10 turns will be for the grid circuit, the permanent earth connection being made on the tenth turn. The remainder of the turns may be tapped out, first with the aerial and then the anode tap or, alternatively, the top 10 turns may be severed from the remainder and used as a loose coupled aerial circuit, leaving the 20 or 30 turns in the middle of the coil for closed circuit tap and anode tap. Owing to the difficulty of building a cylindrical edgewise wound coil a square coil edgewise wound with 8″ sides is much easier to construct and is equally efficient. Bending the corners is quite easy with narrow strip and consequently strip ¼″ wide may be preferred. The operation is not difficult provided the strip metal is soft copper and not a special hard bronze. The edgewise wound spiral with the requisite number of turns can be mounted in four pairs of ebonite strips in which sawcuts have been made at intervals of ¼″. The dimensions given apply to wavelengths between 100 and 500 metres and any excess turns which may not be required for tuning are available for the anode tap.

Although the air spaced coils just described are recommended, another method of winding the aerial inductance which is sometimes favoured is to use an ebonite former about 4″ in diameter, and wind it with single electric light flex tapping out every other turn on to a valve socket, which may be carried by an ebonite strip or panel mounted across the windings. The insulating coverings between the turns if of poor dielectric properties may cause losses particularly on short wavelengths. This form of inductance is more particularly suited to a circuit making use of a coupled grid coil. The latter may be a small cylindrical coil wound on an ebonite former and rotatable inside the larger inductance. Thirty turns of No. 24 D.S.C. is a suitable winding for the grid coil on the wavelength range mentioned and the extent of grid circuit coupling may considerably affect the aerial circuit tuning.

Loose coupled transmitting circuits can be built up by slipping a large diameter coil over the tuning inductance, a portion of which is converted into a tuned closed circuit by bridging it with a condenser. Another form of transmitting loose coupler may be made with a spiral wound helix and placed upon the end of the oscillator coil. Provision should be made for liberal spacing between primary and secondary.

Transmitting Closed Circuit Condenser.—The condenser used for the purpose of creating the closed circuit should, for preference, have air dielectric and one can easily be built up out of zinc plates about 10″ square and supported upon four rods which pass through clearance holes in alternate plates so that diagonally opposite rods hold each set of plates. These should be spaced about 5/16″ apart. Seven plates will make a suitable condenser and the wavelength may be varied by altering the position of the tap on the coil.

Aerial Tuning Condenser.—A variable air dielectric tuning condenser in the aerial lead may be useful in direct coupled sets on wavelengths below 400 metres as its impedance on the short wavelengths is almost negligible and it assists the setting up of oscillations in the circuit. Its use changes the position of the nodal point in the oscillatory circuit and perhaps to some extent alters the formation of the wave front emitted from the aerial.

The Aerial Ammeter.—It is advisable to arrange the aerial ammeter in the aerial lead for if placed on the earth side of the inductance it may easily be burnt out when the H.T. supply is obtained from an earthed source. A switch might be connected across the meter to short circuit or partially short circuit it after the transmitter has been tuned, in order to remove its resistance which, in the case of a low reading meter, may be of appreciable value as compared with the total resistance of the aerial circuit.

Anode Tap.—Returning, again, to the oscillator it is a good plan to connect a coil holder in the anode tap lead which normally may be short circuited with a plug but can be made use of for introducing additional turns in the anode tap circuit by inserting a small coil of a suitable size. A coil would be plugged in this socket when there is difficulty in getting the circuit to oscillate. This would probably not be needed with a loose coupled transmitter, which is in general more satisfactory than a direct coupled set.

The Anode Feed Condenser.—The feed condenser usually connected between plate and anode tap normally has a value of 0·002 mfds. in small telephony transmitters. Its value must not be made appreciably larger than this otherwise the extent of modulation will be diminished. This condenser should be of good quality and suitable for use with very high potentials at radio frequency. Good mica condensers are recommended, built to withstand some thousands of volts by connecting a number of condensers in series.

Transmitting Grid Condenser and Leak.—The grid circuit condenser should also be of good insulation and have mica as a dielectric and a usual value is 0·002 mfds.

The grid leak which usually has a value between 6,000 and 10,000 ohms is composed of resistance wire. A former for winding the wire can be made from a good piece of millboard, thick mica sheet or 1/8″ ebonite. A piece measuring 7″ × 2½″ may have twelve slots about ¼″ in depth and width and opposite to one another in the longer sides and these will carry the winding of resistance wire which should be No. 38 or 40 S.S.C. By winding the resistance as twelve sections the voltage will be distributed along it with the elimination of risk of breakdown. It is a good plan to build several resistances and box them up with terminals so that by altering the leads to the terminals various resistance values can readily be obtained. The fact that this grid leak is somewhat inductive is of small account and removes the necessity of inserting a choke coil in series with it. It should have low self-capacity to avoid capacity leakage across it.

The H.F. Choke.—The plate current is usually fed to the oscillator valve through a high frequency choke coil which must effectively keep the oscillatory currents off the supply circuit. For a transmitter operating on, say, 100 metres a small choke of some 200 turns of No. 34 D.S.C. wire on a 2½″ former is quite effective and on this wavelength care must be taken to ensure that the winding has reasonably low self-capacity or there will be a leakage across the inductance. As the wavelength increases it is necessary to introduce a larger choke and the capacity of the winding now not being such an important matter, pile winding can be adopted. The H.F. choke may, of course, be a plug-in coil and the fitting of a suitable socket in the H.T. lead will permit of the choke being changed as required.

Keying.—For a telegraph transmitter, signalling is usually effected

by arranging the key to break the circuit of the grid leak and when the transmitter is properly adjusted almost sparkless keying is obtained. If the circuit fails to oscillate on depressing the key the grid circuit coupling may be slightly increased but the tighter the coupling of the grid coil the greater is the tendency to spark at the key contacts. Another method of keying consists of connecting a 0·1 mfd. condenser on the earth side of the grid coil, or on the grid side in the case of a single circuit oscillator, and short circuiting it with the key. Additional contacts may be fitted on the key to introduce an artificial load when the running is rendered erratic by signalling. In the case of rectified H.T. supply it is advisable, also, to break the primary circuit of the step-up transformer when keying in order to relieve the strain thrown on the condensers when the grid leak circuit is broken.

I.C.W.—To produce interrupted C.W. a small motor driven drum interrupter should be connected in the grid leak circuit. A buzzer with additional contacts may be arranged to serve the same purpose.

Grid Modulation.—For telephony transmission grid or choke control modulation may be employed. In the former the microphone transformer is usually fitted in the grid circuit, the secondary being bridged with a condenser of a value between 0·01 and 0·001 mfds.

In another system of grid modulation the microphone secondary is connected between the grid itself and the L.T. minus, with the grid condenser in the lead to the grid coil and this time not fitted with a leak. It is necessary in this circuit, particularly on short wavelengths, to fit a high frequency choke between the end of the secondary and the grid lead in order that there may be no serious oscillation leakage through the capacity of the microphone transformer winding.

Little space is given to grid modulated transmitters in this book as the relation between the biassing grid potentials set up by the microphone transformer and the current in the aerial is not linear. The method probably survives on account of economy.

Choke Modulation.—Plate voltage variation by a choke control modulator is probably the most successful method. The low frequency choke coil for grid modulation should have infinite impedance over the entire range of speech frequencies but the size of this coil is of course limited by resistance losses and, moreover, the power transferred to the oscillator decreases as the impedance of the choke is increased. In practice best results are obtained when the impedance of the choke coil is equal to twice the resistance of the oscillator and modulator valves when they are connected in parallel. An inductance value of between 4 and 6 henries gives good modulation and may consist of about $2\frac{1}{2}$ lbs. of No. 28 S.C.C. wound with thin insulating paper between every layer on an iron wire core 5″ in length and 1″ in diameter. There is considerable latitude in these dimensions and the secondary of a transformer can frequently be found to serve the purpose quite well.

A suitable microphone transformer for use with a solid back microphone which may be regarded as having an average resistance of 70 ohms may have a core diameter of $\frac{5}{8}$″ and length $3\frac{1}{2}$″, wound with a primary of four layers of No. 26 D.S.C. and a secondary of 9 ounces of No. 34 S S.C. with thin paper insulation between each layer. Here again, an old $\frac{1}{2}$″ spark coil can be made to do service although it may be necessary to pull out the core and rewind the primary with more turns.

A non-inductive leak having a resistance of about 1 megohm may be connected across the secondary for the purpose of reducing distortion. Grid cells will also probably be necessary in the modulator grid circuit and the actual voltage used must be found by experiment, as must many of the other adjustments of the entire transmitter.

Sources of H.T. for Transmitters.—Usually one of the greatest problems in installing a valve transmitter is that of obtaining a convenient supply of high voltage current.

Dealing briefly with the many methods, the case of the experimenter who has not public current supply mains available might first be considered. High tension batteries might be ruled out as being altogether too expensive for progressive experimental work and his best course is to step-up to high potential by means of an induction coil and rectify with a valve. When the output is bridged with large high voltage condensers and the interrupter is running smoothly at high speed an H.T. supply suitable for telephony can be obtained. The rectifier valve filament must be heated from an independent accumulator and well insulated from earth as the rectifier filament is the positive pole of the H.T. Neon Lamps may be used as rectifiers but some difficulty may be experienced to get them to pass sufficient current.

Where a constant source of electric current is available, a motor running any of the usual models of H.T. generator is an effective solution of the problem. A ripple due to the commutator of the machine may be suppressed by feeding the positive output lead through a large choke and connecting large capacity condensers across the poles of the machine on either side of the choke.

With A.C. at comparatively low periodicity the best plan is to drive a high tension generator with an A.C. motor though the mains may be supplied directly to a step-up transformer, the output of which is rectified with a battery of nodon cells. This scheme can be successfully worked though it is rather difficult to obtain a smooth output. Valve rectifiers with smoothing circuit do the job much better. Synchronous motor driven rectifiers are worthy of consideration for telegraphy.

If a machine is procured which can be driven from the supply mains and has an A.C. output at a frequency exceeding 300 there is not the slightest difficulty in obtaining perfectly smooth high potential D.C. by stepping up and rectifying with valves and feeding through a simple smoothing circuit. A synchronous rectifying high tension commutator fitted to its shaft may give suitable rectification after the potential has been stepped up. The filaments of the rectifier valves and, if possible, the filaments of oscillator and modulator should be heated with alternating current. Step-down transformers will provide for the necessary insulation of the filaments and zero potential connections can be obtained at the mid-points of the windings.

MISCELLANEOUS

Many miscellaneous diagrams will be found in the circuit pages, all having special applications and being suited to the circumstances met with in experimental work. These circuits are not classified here as the foregoing pages describe the more popular circuits and introduce to the beginner present day amateur practice.
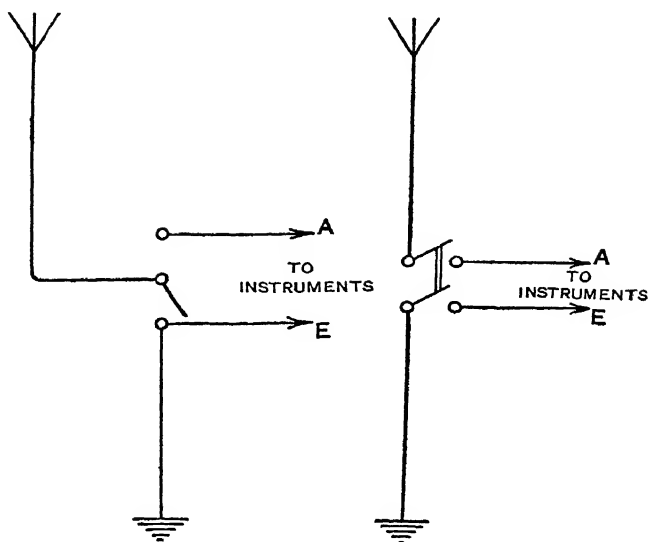
On the left a method is shown of arranging a single pole two position switch so that the aerial may be earthed when not in use. The leads from the aerial and the point of earthing should be taken by a route as direct as possible to the switch which may, if necessary, be fixed out of doors though it must be in a position protected from moisture and the weather.

A double pole switch more completely disconnects the instruments from the aerial leads as shown in the right hand diagram.

The fitting of an aerial earthing switch is recommended and is insisted upon by certain of the insurance companies though it is frequently satisfactory to fit only a lightning protecting device to the receiving apparatus.

Another simple method of earthing consists of terminating the aerial on a plug which can be inserted either into an aerial socket terminal on the receiver or to a socket which is joined to the earth lead. In addition, an earth connected socket may be arranged out of doors so that the lead-in wire can be passed out and earthed entirely away from the building. This completely eliminates all risk of damage by lightning during severe storms.
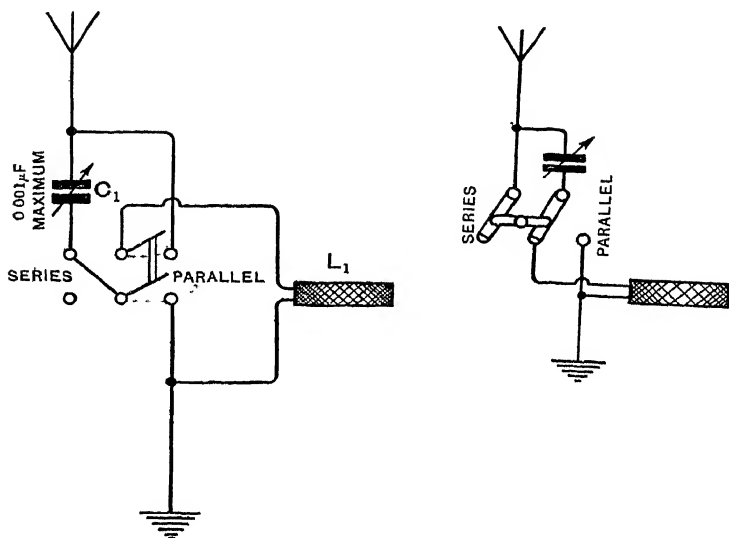
When receiving on short wavelengths, it is customary to connect the aerial tuning condenser in series with the aerial tuning inductance, whilst for the longer wavelengths the condenser is more usually arranged across the inductance   These circuits show various methods of changing the condenser over from the series to the parallel position

An ordinary double pole two position switch, either of the throw-over type as shown in the left hand diagram, or of the slide across pattern shown on the right, will conveniently make the necessary circuit changes

SERIES-PARALLEL CONDENSER SWITCHING—
H.B. 5
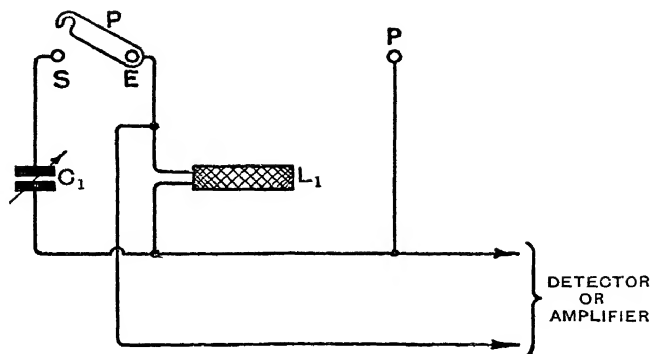
A more simple arrangement consists of providing an additional terminal on the receiving instrument and a connecting link. The condenser C_1 is in series with the inductance L_1 when the aerial lead is joined to the terminal S and the earth to the terminal E with the connecting link open. The condenser and inductance are connected in parallel when the link is closed and the aerial wire connected to S or E and the earth to the terminal P.

The series position whilst producing a shorter wavelength range provides sharper tuning than the parallel arrangement, by which is meant that the receiver responds only to a narrow band of wavelengths and interference by stations operating on adjoining wavelengths is eliminated. In the series position the aerial resistance is greater than when the condenser is connected in parallel but the consequent cutting down of oscillation amplitude is not serious. Valve receivers making use of high frequency amplification or reaction, oscillate much more readily with a series aerial tuning condenser. Owing to the tendency of the circuit to break into oscillation as the value of the condenser is changed, the parallel arrangement is often adopted when high frequency amplification is employed.
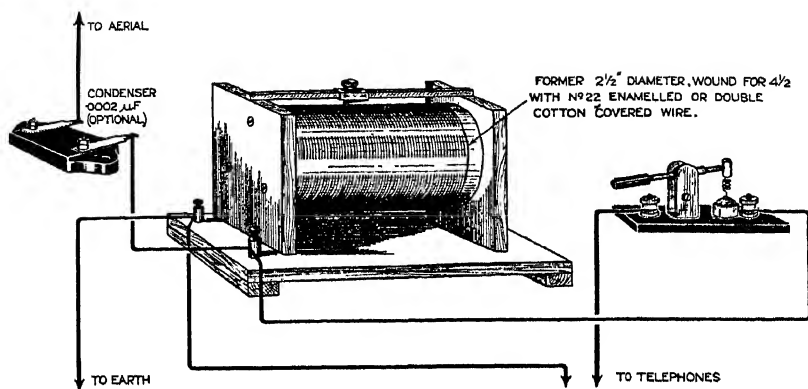
The construction of this set is exceedingly simple. The tuning coil should be wound, if possible, upon a wooden former as the pressure of the sliding contact may force a strawboard tube out of shape, though of course the latter is often employed and serves the purpose fairly well. If strawboard tube is used it should be dried out in warm oven immediately before winding as it is liable to contain moisture which is not only detrimental from an electrical standpoint but will cause the turns of wire to become loose in the event of the tube drying out after the winding has been put on. An application of shellac varnish will render the former hard and moisture proof. Winding on the wire by hand presents no difficulty. The ends of a strawboard former will need to be plugged with circular pieces of $\frac{1}{4}''$ wood which can be held in position by means of screws passing through the sides of the former. The square ends are attached to these circular pieces. The slide moves on a $\frac{1}{4}''$ square brass rod.

For reception on wavelengths below 700 metres the connection of a condenser in the aerial lead, as shown, is recommended. More turns of wire will need to be included to tune to a given wavelength and usually greater signal strength is obtained.
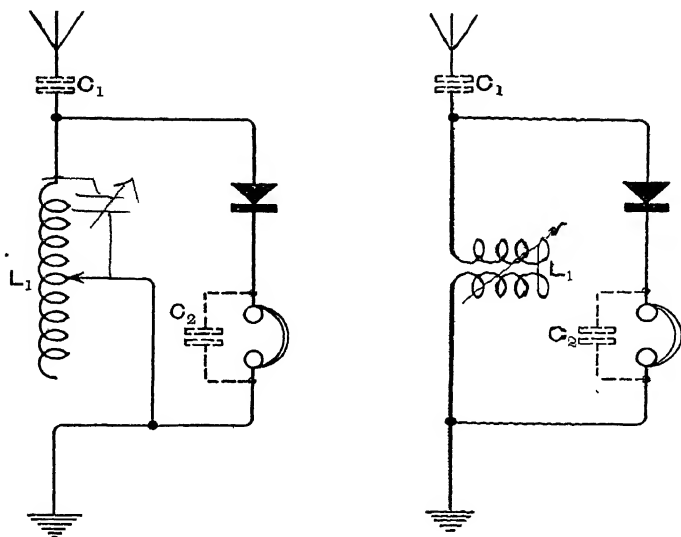
Tuning by means of a sliding contact, as shown in the left hand diagram, is probably the simplest system that can be adopted. As a rule such contact is a little uncertain and a varying number of turns is short circuited as the sliding contact is moved To tune an average amateur aerial to wavelengths between 200 and 800 metres the inductance L_1 should consist of about 160 turns of wire on a 2¾″ former. The wire must necessarily be enamelled in order to facilitate the cleaning of the surface for the sliding contact. No 20 or 22 S W G. is sufficiently durable. The condenser C_1 may produce greater signal strength owing to the necessity of introducing additional turns to tune to a given wavelength It should have a value of 0 0002 to 0·0005 mfds , and C_2 a value of 0·001 mfds. The telephone receivers must be wound to a resistance of at least 2000 ohms particularly when a detector of the galena type is employed.

The right hand circuit shows a variometer tuned crystal receiver. Variometers, to be really effective, should have specially shaped windings leaving a minimum of clearance between moving and fixed turns and those built from cylindrical tubes give a very small and, generally, insufficient tuning range. 70 turns each on rotor and stator is a usual variometer winding The use of the condenser C_1 is recommended as it improves signal strength and sharpens tuning.
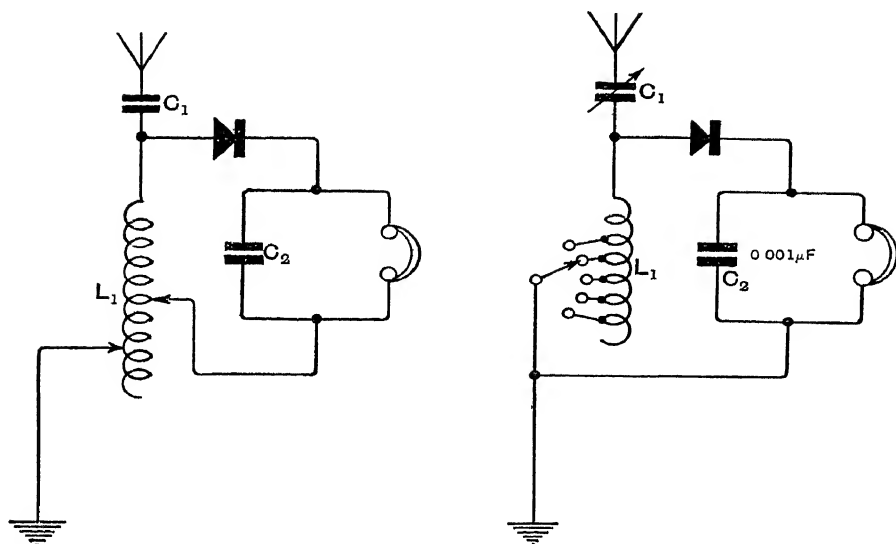
When a crystal detector and telephones are connected across the ends of a tuning inductance the magnitude of the oscillations occurring in that inductance will be considerably reduced   This reduction in magnitude due to the comparatively low resistance of the crystal and telephones circuit, and known as damping, has the effect of considerably broadening the band of wavelengths to which the receiver will respond This is why some crystal receivers possess such flat tuning and are so liable to interference by jamming   The diagram on the left shows a method by which only a portion of the tuning inductance is bridged by the crystal and telephones.   Using this arrangement the signal strength may be improved as compared with the method by which the entire inductance is bridged.   Tuning is rendered sharper owing to the reduced damping and selectivity may further be improved by the series aerial condenser C_1 which may have a value of about 0·0002 mfds , when tuning to wavelengths below 600 metres.   The aerial condenser need not be variable as the inductance is rendered continuously variable by the sliding contacts.   The use of a two slide tuner does not allow for providing a potential step-up which can only be obtained by the use of loosely coupled coils   For wavelengths of 200 to 600 metres L_1 may consist of 160 turns of No 22 enamelled wire on a $2\frac{3}{4}''$ former.

The right hand diagram shows another method of varying the inductance in an aerial tuning circuit.   The first tapping may be at the 30th turn and the others at the 40th, 55th, 75th, 110th and 160th   The tuning is rendered continuously variable by C_1 which may have a maximum value of about 0·0005 mfds

For tuning to wavelengths up to 2000 metres 250 turns of No 26 D C C. will be required wound on a 3″ former and the condenser C_1 should be connected across the ends of the inductance instead of in series with it as shown.

When tuning to wavelengths of over 800 metres with a crystal receiver, the condenser C_1 should be connected in parallel across the inductance. The selectivity of this parallel condenser circuit can be improved by introducing a series aerial condenser which may be of fixed value if the receiver is not required to operate over a very extensive wavelength range. For wavelengths up to 2000 metres C_1 should not exceed 0·0005 mfds. For longer wavelengths its value may be 0·0015 mfds. The value of C_2 is similar.
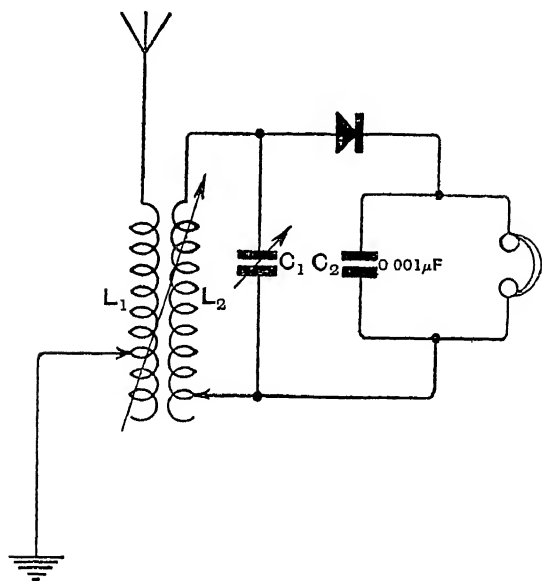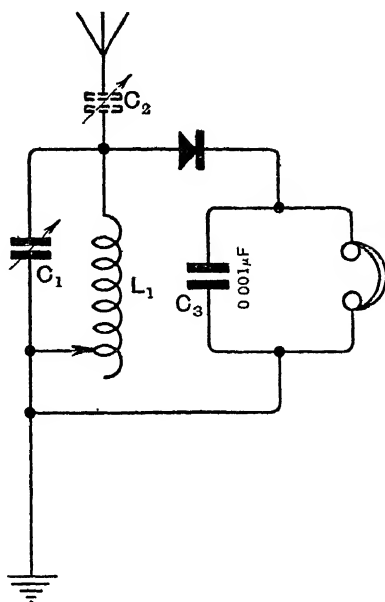
A loose coupled receiver is less liable to interference by jamming than the more simple arrangement employing a single inductance. Many forms of construction may be adopted for the inductances L_1 and L_2. The aerial inductance L_1 may be wound upon a cardboard former some three or four inches in diameter and a sliding contact provided, while L_2 may be made to move inside L_1 and have tapping points arranged by means of a multi-stud switch. If L_1 is arranged as a tapped coil it will be necessary to introduce a variable condenser either in series or parallel with the inductance. Alternatively the two coils may be of the plug-in type, whilst a pair of basket coils supported so as to swing or slide apart serves the purpose very well. A point often overlooked in operating a receiver of this sort is that the wavelength to which the circuit is tuned, changes when alterations are made in the coupling between the coils and slight readjustment of the tuning condensers is necessary.
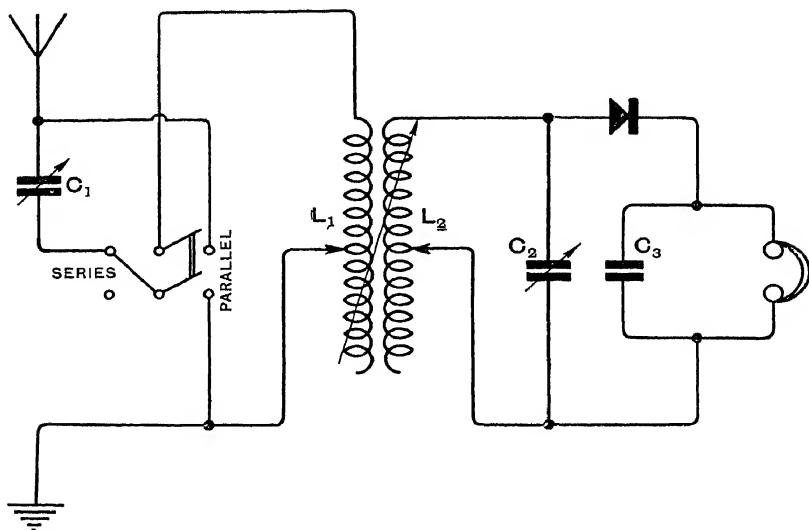
A selective crystal receiver fitted with a switch for connecting the aerial condenser either in series or parallel with the aerial inductance. Loose coupling is made use of which gives good selectivity.

C_1, 0·00075 mfds., C_2, 0·0004 mfds , C_3, 0·001 mfds., L_1, 180 turns No. 24 D C.C $3\frac{1}{2}''$ in diameter. L_2, 250 turns No 26 D S.C. $2\frac{3}{4}''$ in diameter These values will tune up to wavelengths of about 2500 metres
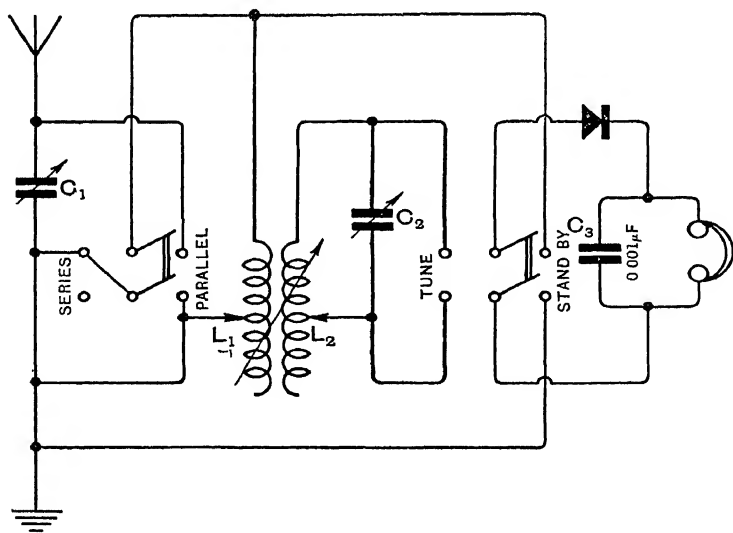
To facilitate tuning an additional switch has been introduced so that the closed circuit can be brought into operation after the desired signals have been tuned in on the aerial circuit By this arrangement just the required degree of selectivity can be provided. Condenser and inductance values may be as above.

SELECTIVE CRYSTAL RECEIVER—H.B.15
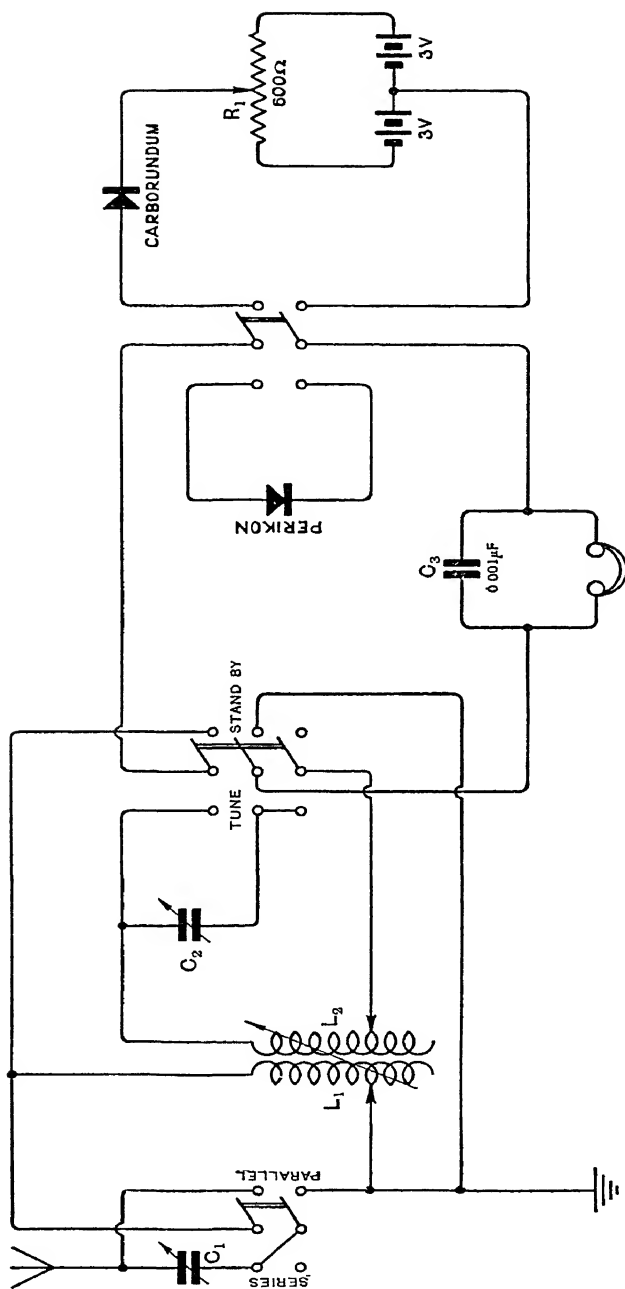
A complete crystal receiver provided with series parallel switching for the aerial tuning condenser, switch for connecting detector circuit directly across the aerial inductance or across the closed circuit inductance and a switch for selecting between two types of crystal detector. It will be noticed that the centre switch has an additional set of contacts which are arranged to disconnect the closed circuit inductance from its condenser so that the closed circuit will have very little influence on the tuning of the aerial circuit when the switch is in the right hand position. C_1, 0·001 mfds., or 0·0015 mfds., maximum for a full range receiver. C_2, 0·0003 to 0·0005 mfds., maximum. C_3, 0·001 mfds. Suitable construction for L_1 and L_2 are given in an earlier diagram and it might be mentioned that inductances for use with crystal receivers should be wound with wire which will not offer excessive resistance and Nos. 20 to 26 double cotton or double silk covered are generally suitable.
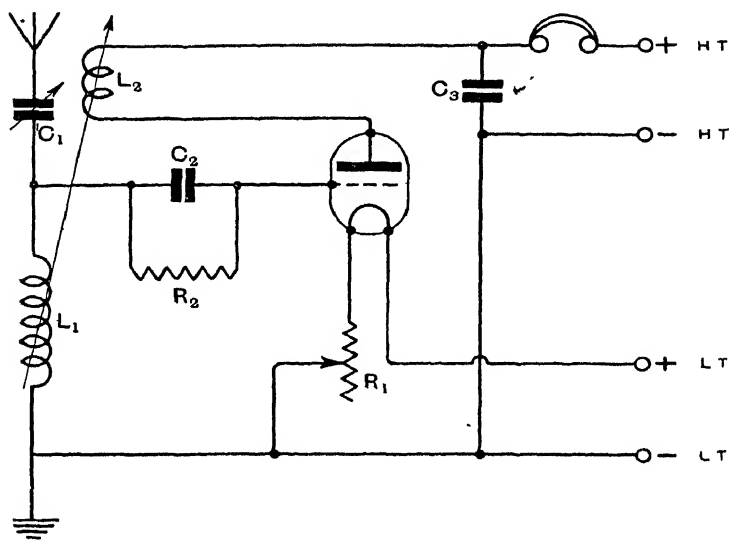
The most usual single valve receiver comprises a tuned aerial circuit with series tuning condenser and reaction coil coupled to the aerial inductance.

C_1, 0·00075 mfds., maximum. C_2, 0·0002 mfds C_3, 0·001 mfds L_1, about 75 turns 2½″ in diameter No 26 D C C. L_2, 60 turns 1½″ in diameter No 30 S S C.

R_1, 10 ohms maximum for " R " and dull emitter type valves taking more than 0·4 amps and 30 ohms for dull emitter types taking 0·06 amps. R_2, 2 megohms

The tuning values given here are suitable for wavelengths up to about 600 metres
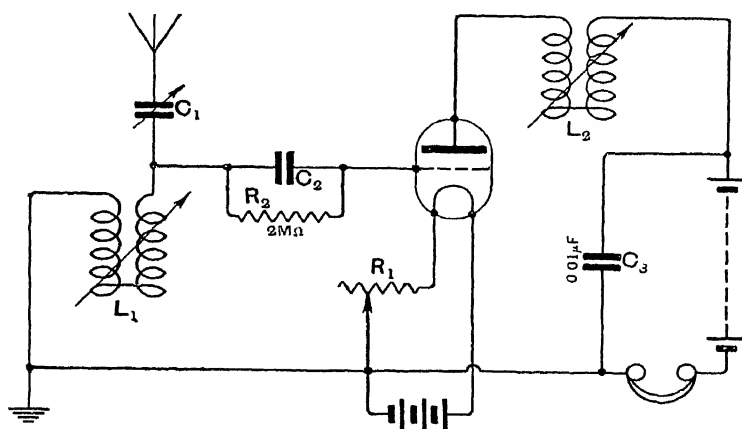
In this circuit the aerial is tuned by means of a variometer while another is introduced into the anode lead to cause the circuit to oscillate. By suitably adjusting the value of C_1 smooth oscillation can be obtained over the whole range of the two tuning variometers.

TELEPHONES

0 0002μF

2MΩ

0 0003μF

REACTION COIL   **+ H.T. —**   **— LT +**   **E**   **A** AERIAL COIL
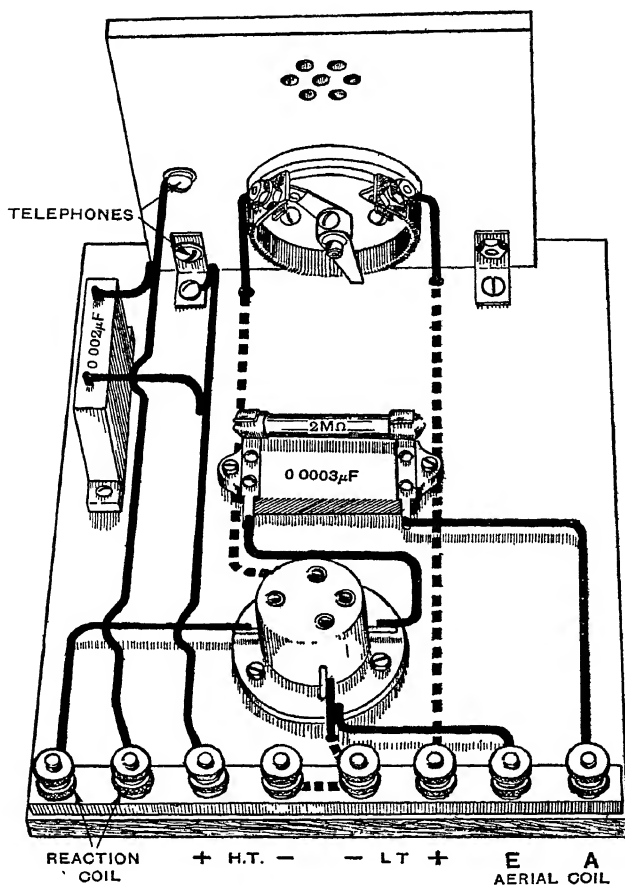
The actual layout and practical wiring is shown here of a single valve receiver built to circuit H B 17   The design is arranged to be as simple as possible and to involve a minimum of work.   The component parts can be readily identified and the relative positions can be easily copied   The diagram shows the interpretation of a circuit from the theoretical to the practical form   Connecting up is carried out with No 18 tinned copper wire and that portion of the leads which is shown dotted may be arranged beneath the panel and in contact with the wooden base   The grid and plate leads are self supporting and out of contact with the wood whilst the terminals are mounted upon a strip of ebonite

The terminals marked A and E are joined to the aerial and earth ends of an aerial inductance which may have a condenser connected in series or parallel with it depending upon the wavelength.   The reaction coil is coupled to the aerial inductance.   The value shown for the grid condenser is chosen as a more usual value for a receiver which may be required for use on long wavelengths and 0·0002 mfds is usually employed in sets working on wavelengths below 500 metres.   The telephone condenser is shown as 0·002 mfds, and is a value that is sometimes used instead of the usual 0·001 mfds
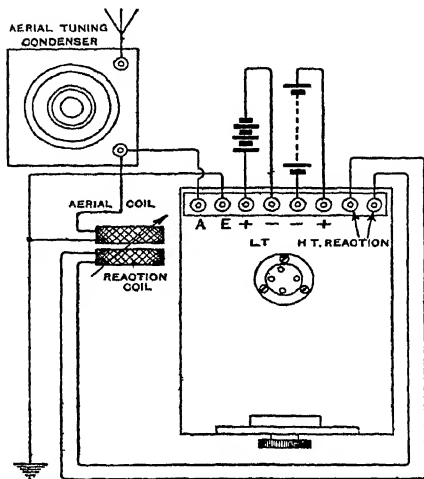
The external connections of the detector valve panel described on the previous page are shown here.
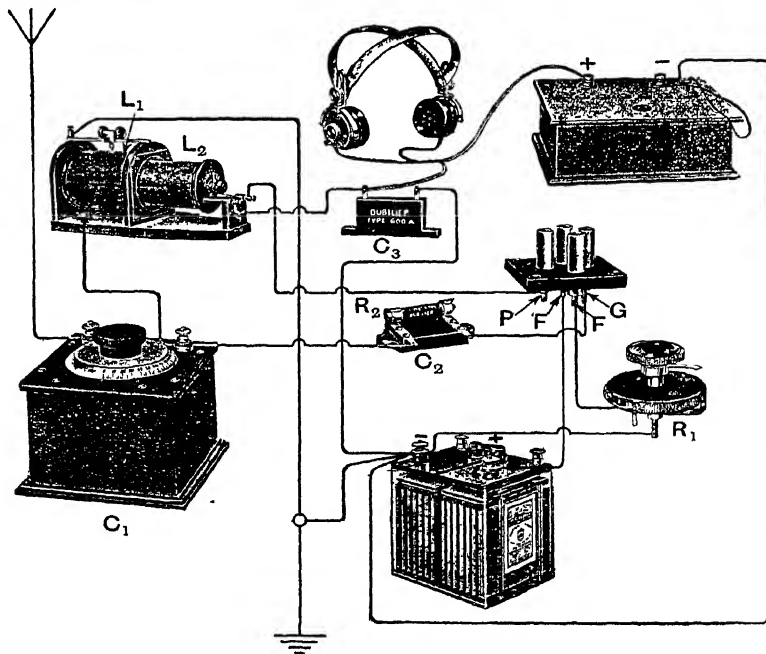
This figure represents a single valve receiving set wired up from a number of component parts. The leads indicate the actual points between which connections are made and are not taken by the shortest routes for the object of producing a clear diagram.

It will be seen that where a number of wires have to be connected together that this is done on an instrument terminal and not by baring the insulated leads and jointing wires.

RECEIVER WITH CRYSTAL OR REACTING VALVE DETECTOR—H.B. 21
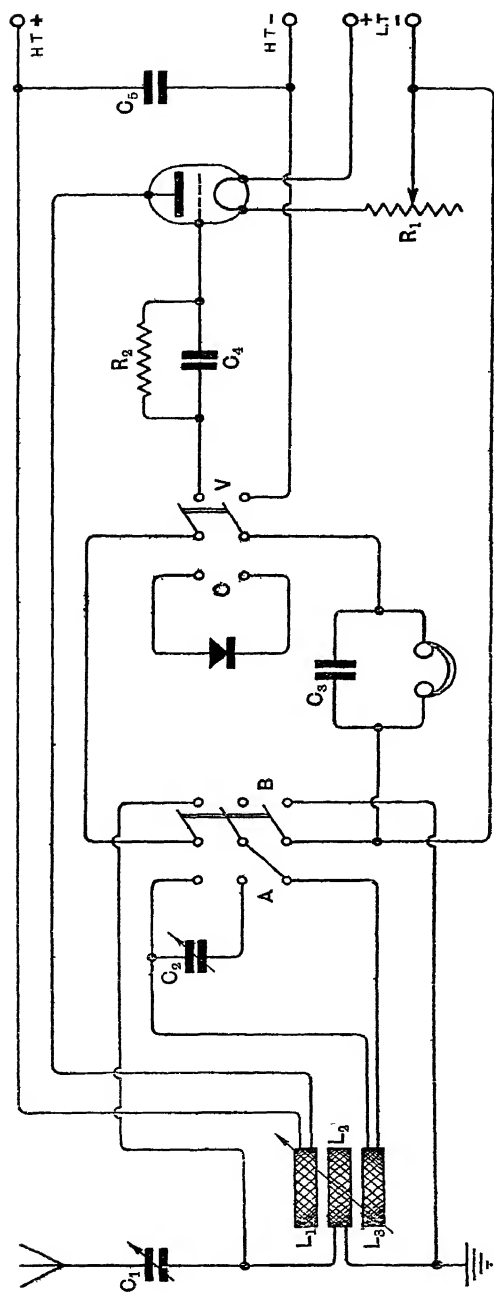
A switch is shown in this receiver for introducing a tuned closed circuit and it will be noticed that it is fitted with 3 arms, and breaks the tuned closed circuit when in the position B so that the closed circuit inductance will not influence the tuning of the aerial circuit.

By means of a double pole two position switch it is possible to change from crystal to valve reception. In order that the telephone receivers may be thrown in circuit with either the crystal or the plate lead of the valve it is necessary to connect them on the negative of the high tension battery and thus with this circuit it is not possible to add note magnifiers working from the same H.T. supply and should this be required it will be necessary to employ a more complicated switching arrangement.

C_1 maximum 0·00075 or 0·001 mfds. C_2 maximum 0·0003 mfds. C_3 0·001 mfds. C_4 0·00025 mfds. C_5 is not essential in the single valve receiver and may have a value from 0·001 up to 2 mfds. R_2 2 megohms.

R_1 10 ohms maximum for bright emitter valves or 30 ohms for dull emitters. R_2 2 megohms.

L_1 L_2 and L_3. See tables according to wavelength.

The change-over switches must be of the low capacity type specially designed for use in high frequency circuits.

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SINGLE VALVE RECEIVER FOR 300 TO 25,000 METRES—**H.B. 22***
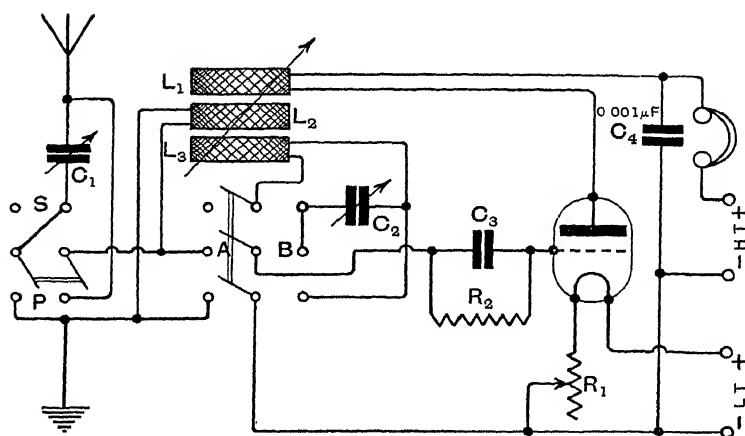
This is a standard single valve circuit fitted with a tuned closed circuit and reaction. Plug-in coils are shown for the purpose of tuning over the entire wavelength range and for this reason the aerial and closed circuit tuning condensers are made of slightly larger value than if the set were restricted in its use to only short wavelengths. When the centre switch is in position " A " the closed circuit is not in operation and an additional arm is fitted on the switch which will break the closed circuit and prevent it influencing the aerial.

C_1, 0·0015 mfds., maximum. C_2, 0·0004 mfds , maximum. C_3, 0 00025 mfds. C_4, 0·001 mfds. L_1, L_2, L_3, according to wavelength. R_1, 10 ohms maximum, or for dull emitter valves passing a current of less than 0·1 amperes 30 ohms maximum.
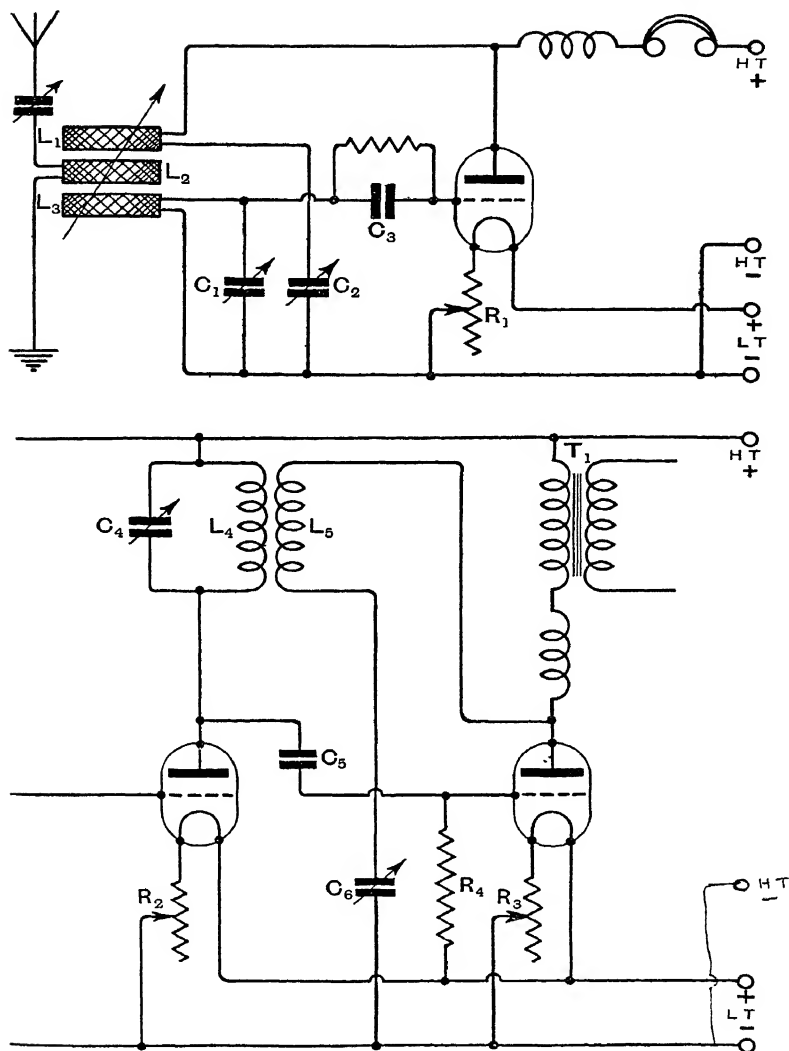
The novelty of this circuit is the method by which reaction is obtained. The upper figure shows reaction on to the aerial circuit, and in the lower, on to the tuned anode inductance of the high frequency amplifier. The value of the condensers C_2 and C_6 should be kept reasonably low to prevent the shunting away of currents of speech frequency. A plug-in inductance should be used for the choke coil so that larger inductances may be inserted as the receiving wavelength is increased. Reaction is increased as the capacity of the condensers C_2 or C_6 is made greater. These have a maximum value of 0·0005 mfds.

The values for the components are the same as for those shown in other single valve and tuned anode circuits.
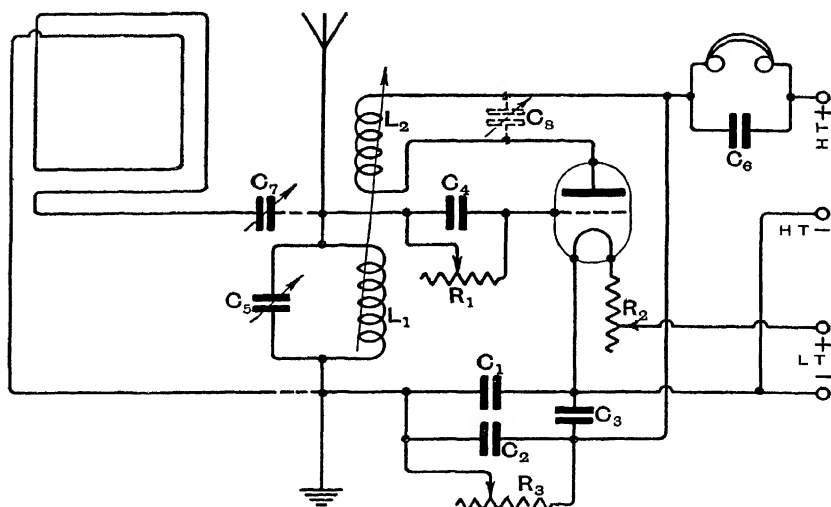
This circuit is critical in its adjustments and experience is necessary before super-results can be obtained. R_1 and R_3, 0·5 to 3 megohms. C_1, C_2, C_3, 0·006 mfds. C_4, 0·0002 mfds. C_5, 0·0003 mfds., maximum C_6, 0·001 mfds. C_7, 0·0005 mfds., maximum. C_8, 0·0002 mfds. L_1, and L_2, usual values for aerial and reaction inductances.
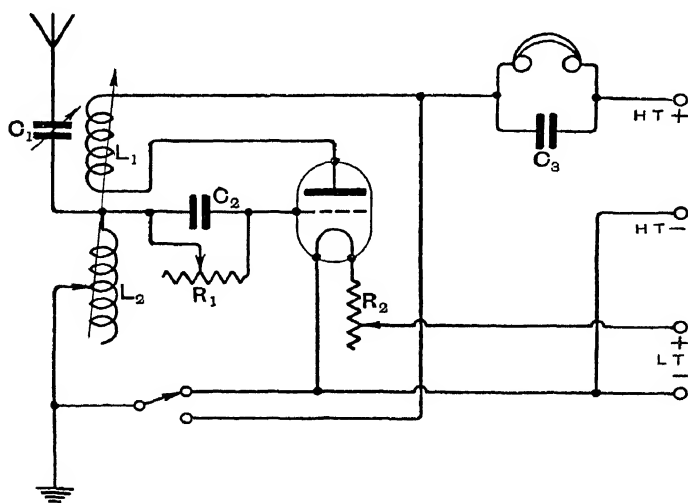
Periodic damping is produced in this circuit by adjusting the resistance R_1 and connecting the lower end of the inductance to the H.T lead. This permits of tighter reaction coupling as is usual in super-circuits of this class. Best results are usually obtained on a frame aerial and the circuit may be converted to a normal one by the use of the two-way switch shown.

TUNED ANODE H.F. AMPLIFIER—**H.B. 27***
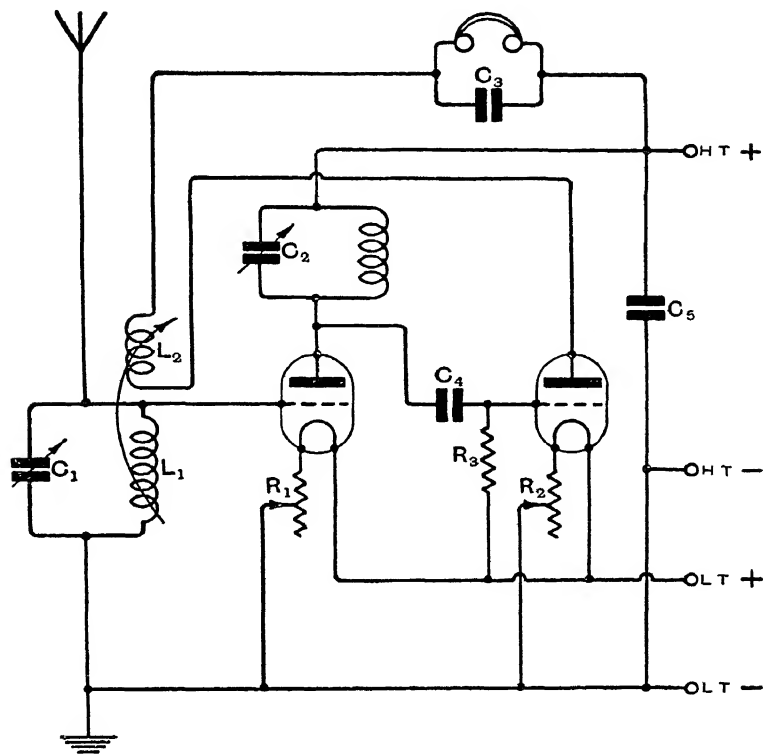
The simplest and possibly the most efficient method of obtaining amplification at high frequency is by the tuned anode method   In the circuit shown the aerial inductance is tuned with a parallel condenser which renders the circuit stable but on short wavelengths does not produce quite such good signal strength as a series aerial tuning condenser which, however, has the disadvantage of producing rather critical reaction control.

The reaction coil is shown coupled to the aerial circuit and sets up oscillation in the receiver   This is necessary for the reception of continuous wave signals and for bringing in weak telephony   When adjusting the reaction coil one usually regulates the coupling until the " silent point " is reached.   Extreme range is obtained by this method though distortion will be introduced into telephony and interference caused on near-by receiving sets which may be attempting to tune to the same transmission

Self-oscillation may, if desired, be reduced in the tuned anode coil by inserting a resistance either in the oscillatory circuit or the tuned anode lead, having a value of a few thousand ohms   Another method consists of connecting a clip-in resistance having a value between $\frac{1}{10}$ and $\frac{1}{2}$ megohm across the tuned anode circuit

C_1, 0 0003 or 0 0005 mfds maximum C_2, 0 0002 mfds , for wavelengths up to 800 metres and 0 0005 mfds , for wavelengths up to 3,000 metres C_3, 0 001 mfds C_4, 0 00025 mfds C_5, 1 or 2 mfds. L_1, L_2, and tuned anode coil according to wavelength but for 400 metres L_1 may be a 50 or 75 coil, L_2, 75 or 100, and tuned anode 75, or the equivalents of these coils in other methods of winding R_1 and R_2 10 ohms, or 30 ohms for 0 06 dull emitters. R_3, 2 megohms.

H.F. (TUNED ANODE) AND VALVE DETECTOR—
H.B. 28*

Practical Wiring

This diagram shows the actual practical wiring of a two-valve receiver having one high frequency valve connected on the tuned anode principle and a valve detector It is useful where extreme range is desired and further increase in signal strength can be obtained by adding a one or two valve note magnifier. The values of the components are as given on the previous page and the use of coil holders makes the receiver suitable for reception on all wavelengths.

A receiver of this kind should be connected up with stiff wire, preferably No 16 S.W G tinned. This wire may be straightened by stretching and some practice is needed in its use to make a really good job though it should not be beyond the skill of any amateur who exercises reasonable patience. Soft tinman's solder is used for jointing.

SWITCHING A TUNED ANODE H.F. AMPLIFIER—
H.B. 29
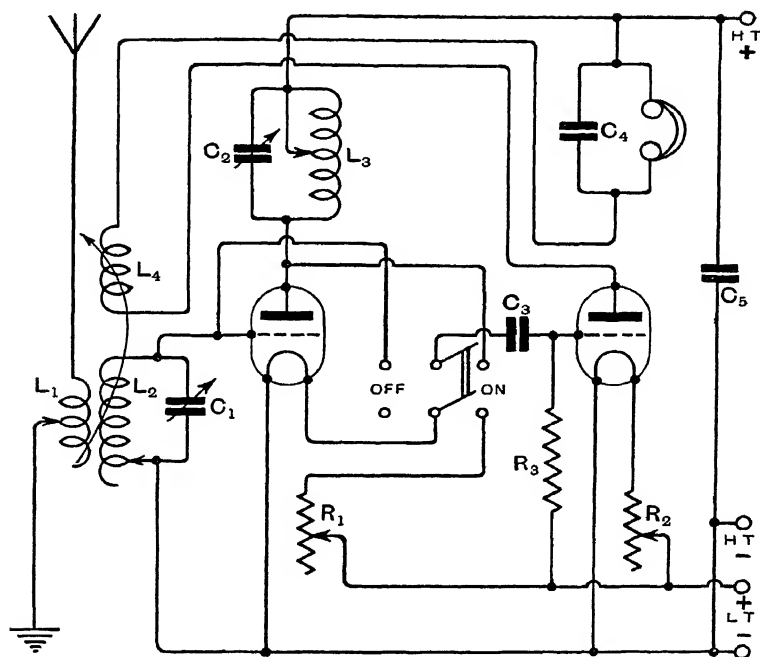
It is not always desirable to make use of the high frequency amplifying valve as it renders tuning rather complicated and produces little or no increase in the volume of normally strong signals. For this reason switching is introduced.

Care must be taken with this circuit to make the grid switching leads as short as possible, and connecting up should be carried out with stiff, well spaced wires No loss need be occasioned by the introduction of a switch into a high frequency amplifying circuit.

The values of condensers and inductances may be as indicated in previous tuned anode circuits, though for variety different forms of inductances are shown The coupling between the aerial and closed circuit coils is moderately tight and is not adjustable, whilst the tuned anode inductance is tapped out by short circuiting a portion of the turns

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SWITCHING TWO H.F. (TUNED ANODE) AMPLIFIERS—**H.B. 30**
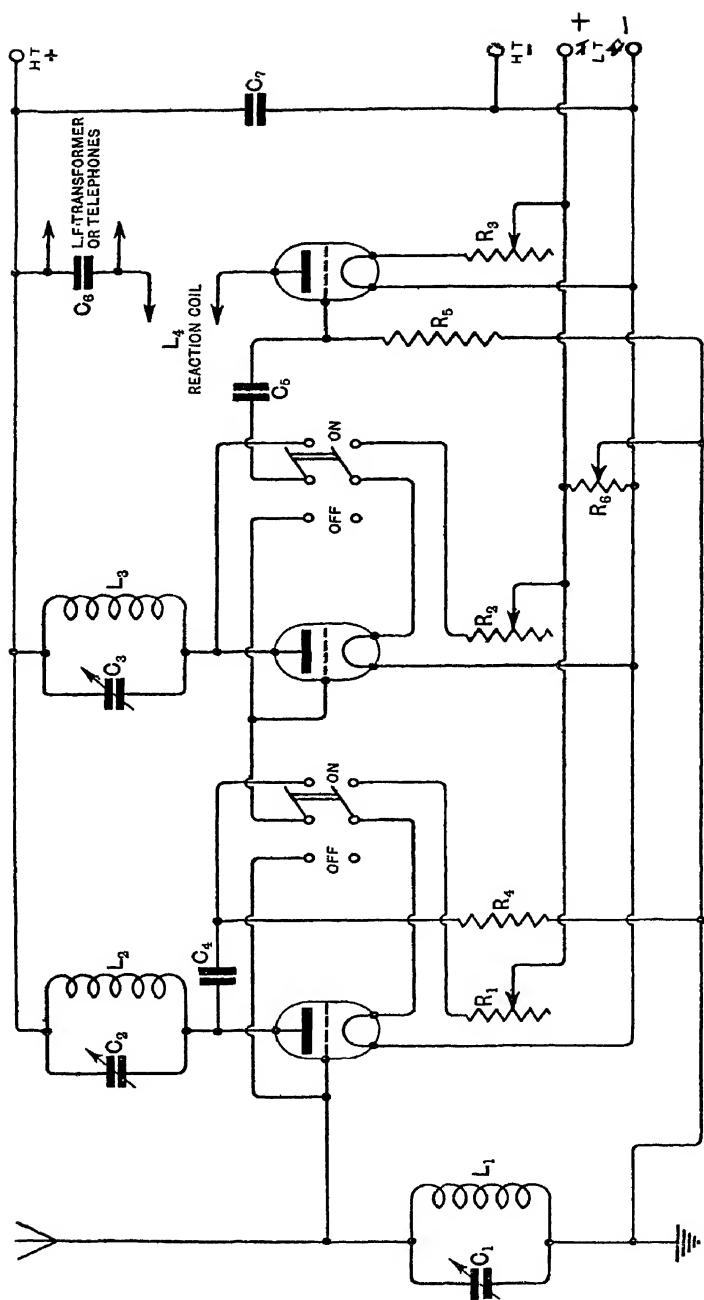
To facilitate the tuning of two tuned anode circuits additional switching is here introduced. An adjustment of the potentiometer R_6 flattens the tuning. Alternatively, this can be done by shunting the tuned anode inductances with resistances having values of about 100,000 ohms. These will render the circuit easier to manipulate, but their use will be accompanied by some loss in signal strength.

TUNED ANODE AND CRYSTAL DETECTOR—
H.B. 31
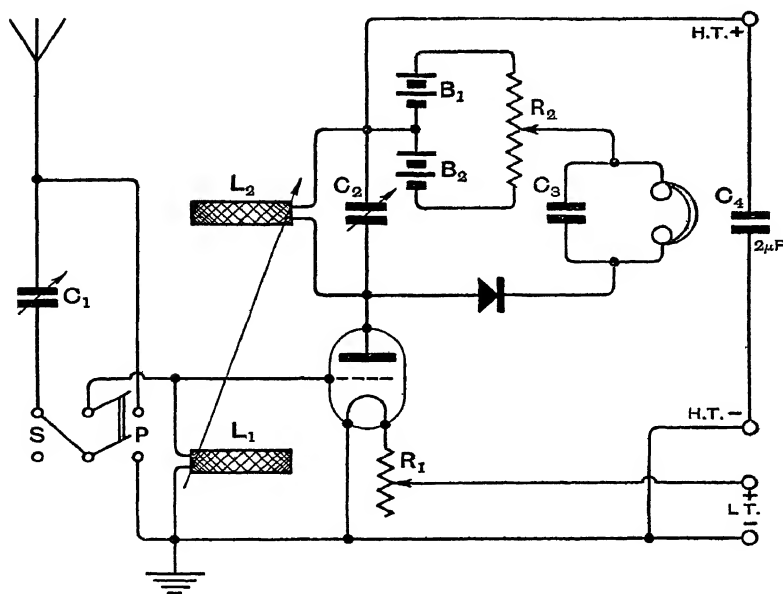
To economise in filament current a crystal is often used as a detector instead of a valve. The use of a carborundum crystal with potentiometer and battery is recommended although other types of crystals not requiring local current sometimes operate satisfactorily. A disadvantage with this arrangement is that the crystal circuit is of such low resistance that the tuning of the anode circuit is rendered somewhat flat and amplification reduced. This is partially overcome by coupling the tuned anode coil to the aerial inductance.

For reception on wavelengths from 200 to 2000 metres C_1 may have a value of 0 0005 or 0·00075 mfds., maximum. C_2 0·0002 or 0·0003 mfds , maximum. L_1, L_2, according to wavelength.

R_1, 10 ohms for " R " valves or 30 ohms for dull emitters taking less than 0·1 amperes. R_2, 200 to 600 ohms. C_3, 0 001 mfds., and C_4, 1 or 2 mfds.
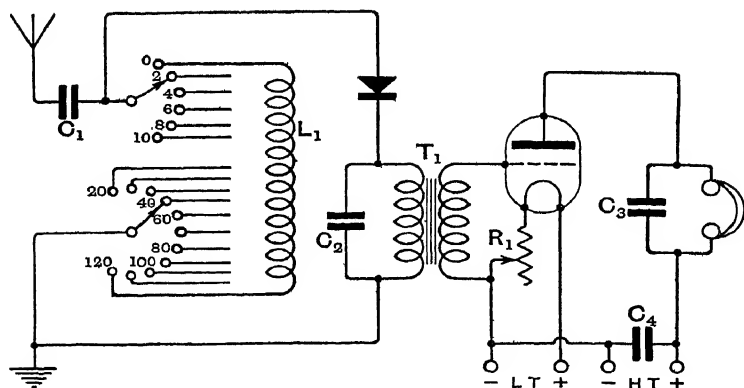
This circuit shows a simple tapped out crystal detector with a single stage of low frequency amplification. The transformer T_1 should have a ratio of 1 to 3, or 1 to 4, and a primary winding of about 8000 turns. L_1 is wound with No. 24 D.C.C., $2\frac{3}{4}''$ in diameter.
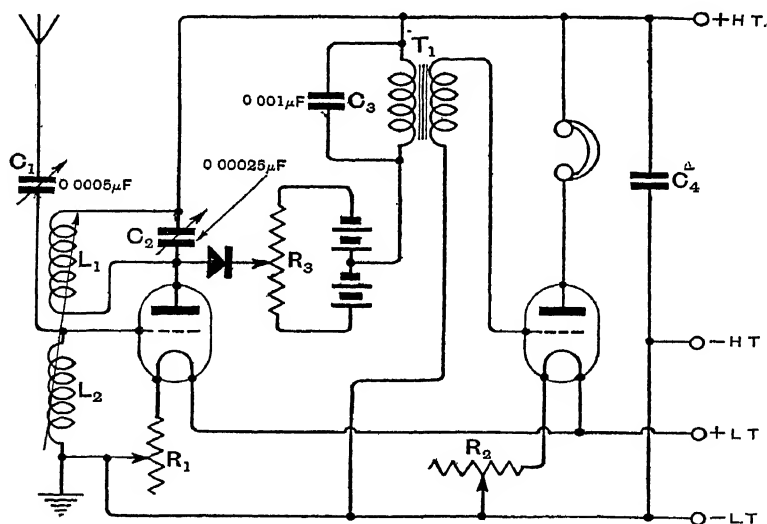
A useful receiver having tuned anode high frequency amplification, carborundum crystal detector and note magnifier.

The point might be mentioned here with regard to operating several valves off a common high tension battery. It is important, particularly where there is a low frequency amplifying valve that the value of the condenser C_4 should not be less than 1 mfd.

USEFUL THREE VALVE SET—H.B. 34*
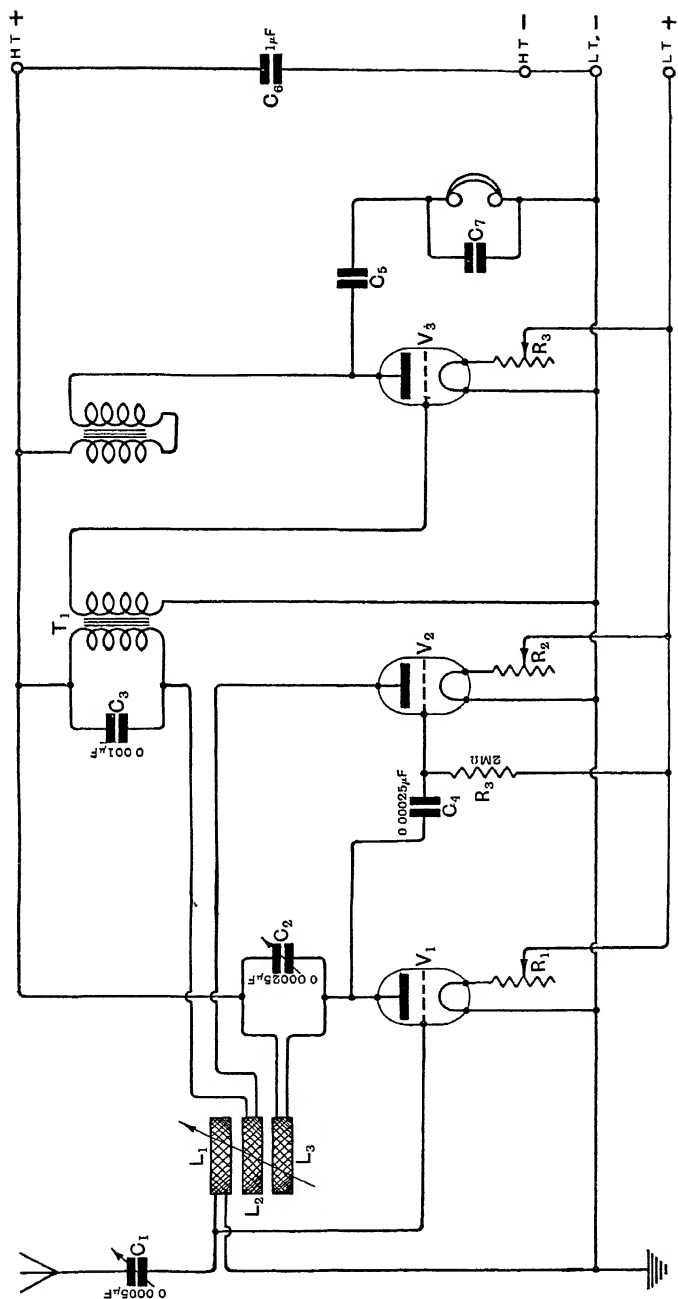
High frequency amplification is obtained by the tuned anode method followed by a valve detector and note magnifier. A feature of the circuit is that reaction is applied to both aerial and tuned anode inductances. The leads to the inductances L_1 and L_2 can be so arranged that reaction is stimulated in the aerial circuit to compensate for its comparatively high resistance whilst the direction of coupling on to the tuned anode has the effect of damping down the tendency that circuit may have to oscillate.

The telephones are fed through a condenser C_5 having a value of about 0·25 mfds. and the telephones themselves are connected to the L.T. minus, so that they are at earth potential, but if the insulating properties of C_5 are at all doubtful they should be connected to the H.T. plus. C_7 is optional and its value may be found by experiment. Quality may be improved by the action of this condenser in altering the resonant note frequency of the telephones or loud speaker.

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THREE VALVE RECEIVER—**H.B. 35***
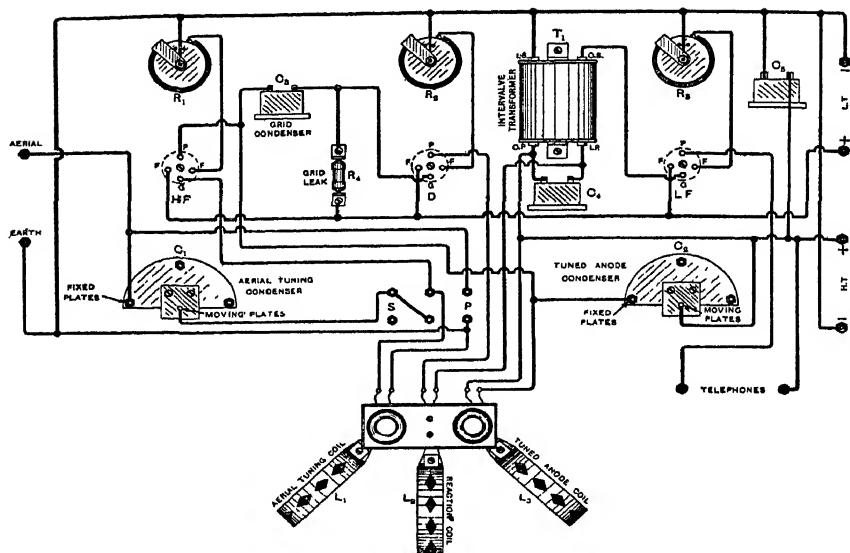
For long range reception with telephone receivers and for loud speaker operation at moderate distances there is nothing better than a three-valve receiver comprising a high frequency amplifier, valve detector and note magnifier

This set has been designed essentially for the experimenting amateur, inasmuch as it is suitable for reception on all wavelengths by the use of interchangeable plug-in coils, and a series-parallel aerial switch. Reaction is arranged on to both aerial and tuned anode coils, and tests should be made to determine which connections give the best results as regards oscillation.

The leads shown give the actual connections of the instrument and when using this diagram it is helpful to mark off the various wires as they are fitted in the set.

The telephones may be connected to the terminals as shown, putting them in the plate circuit of the L F. valve. Alternatively, they may be fed through an L.F. choke and condenser or through a transformer as in other circuits.

C_1, 0·0005 mfds. C_2, 0·0002 or 0·0003 mfds. C_3, 0·00025 mfds C_4, 0 001 mfds C_5, 1 to 2 mfds. R_4, 2 megohms.

The feature of this circuit is the switching method by which a crystal detector is substituted for the valve. Another point in the circuit is the way in which the high resistance telephones are fed through a condenser having a value of about 0·25 mfds. (C_6) so that the constant plate current is not fed through the telephone windings. The iron core choke coil may be the primary, secondary or both windings of an intervalve transformer. Values are as shown in earlier circuits.

VALVE OR CRYSTAL DETECTOR SWITCHING—H.B. 37
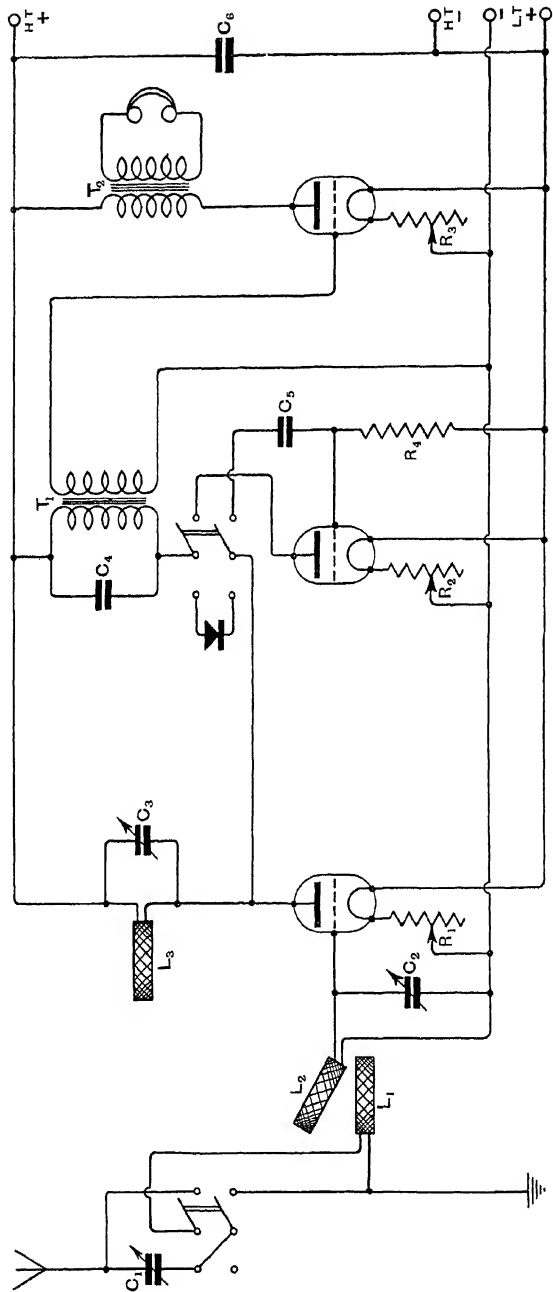
A somewhat similar arrangement to the previous circuit though employing another type of crystal, without battery and potentiometer. A loose coupled aerial circuit has been introduced and when using the crystal detector it is necessary to couple the tuned anode coil L_3, with the aerial inductance L_1. A telephone transformer overcomes the difficulty of feeding the constant plate current through the telephone windings and should have a step-down ratio for low resistance telephones or about a 1 to 1 winding for the high resistance type.

SIMPLE VALVE SWITCHING IN FOUR-VALVE RECEIVER—H.B. 38*
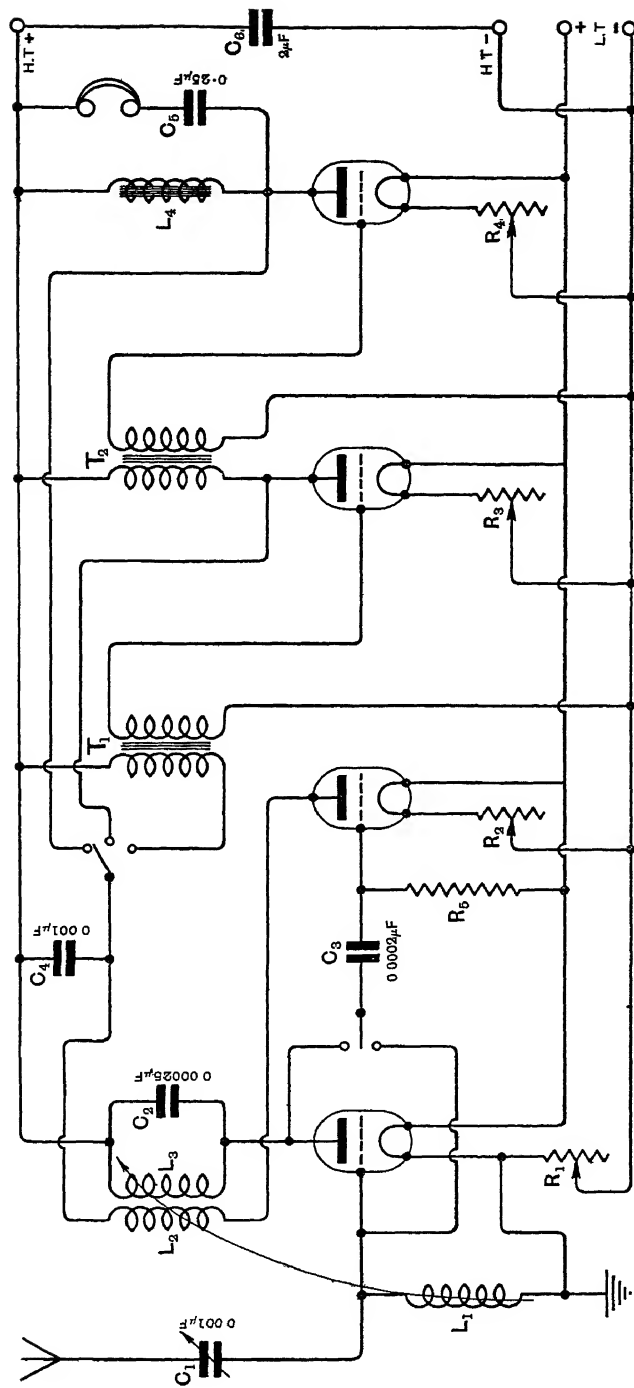
The simplest method of valve switching has here been introduced and a receiver built to this circuit might be described as a good all-purposes set. The H.F. switch is quite simple and should not give rise to loss of efficiency. Both L.F. valves are in circuit when the L.F. switch is in the bottom position, in the middle position the first L.F. valve is out and in the top, both L.F. valves are cut out. Filaments of valves not in use must be switched off by means of "off" positions on the filament resistances.

The values of the components can be taken from earlier circuits or the introductory pages. C_2, the tuned anode condenser is variable and reaction may be arranged on to aerial and tuned anode windings

UNIVERSAL FOUR-VALVE RECEIVER—H.B. 39
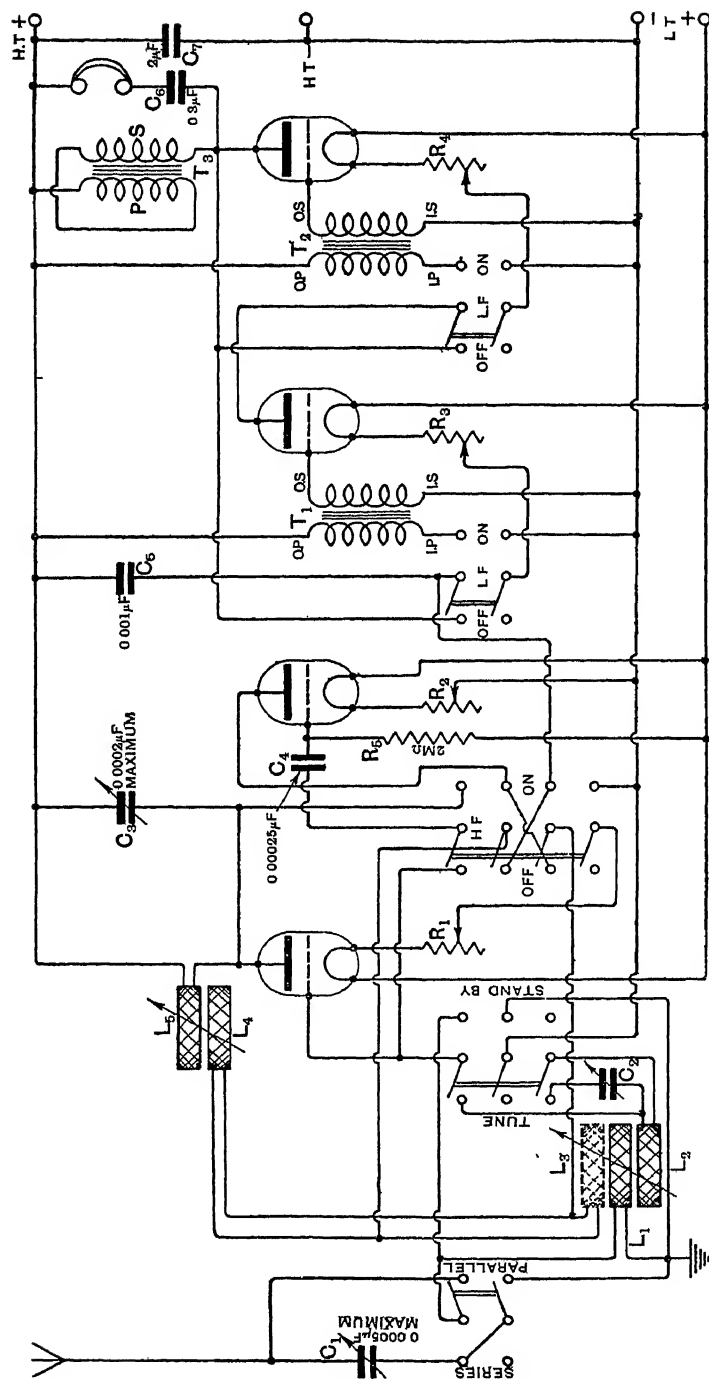
In spite of the switches this is a thoroughly efficient receiving circuit and permits of the use of a circuit arrangement suiting conditions as required   One of the switches provides for the introduction of a tuned closed circuit which is most useful for the elimination of interference and in facilitating the manipulation of the high frequency amplifier.   The closed circuit condenser C_2 may have a maximum capacity of 0·00025 mfds.

PRACTICAL WIRING OF FOUR-VALVE RECEIVER—H.B. 40
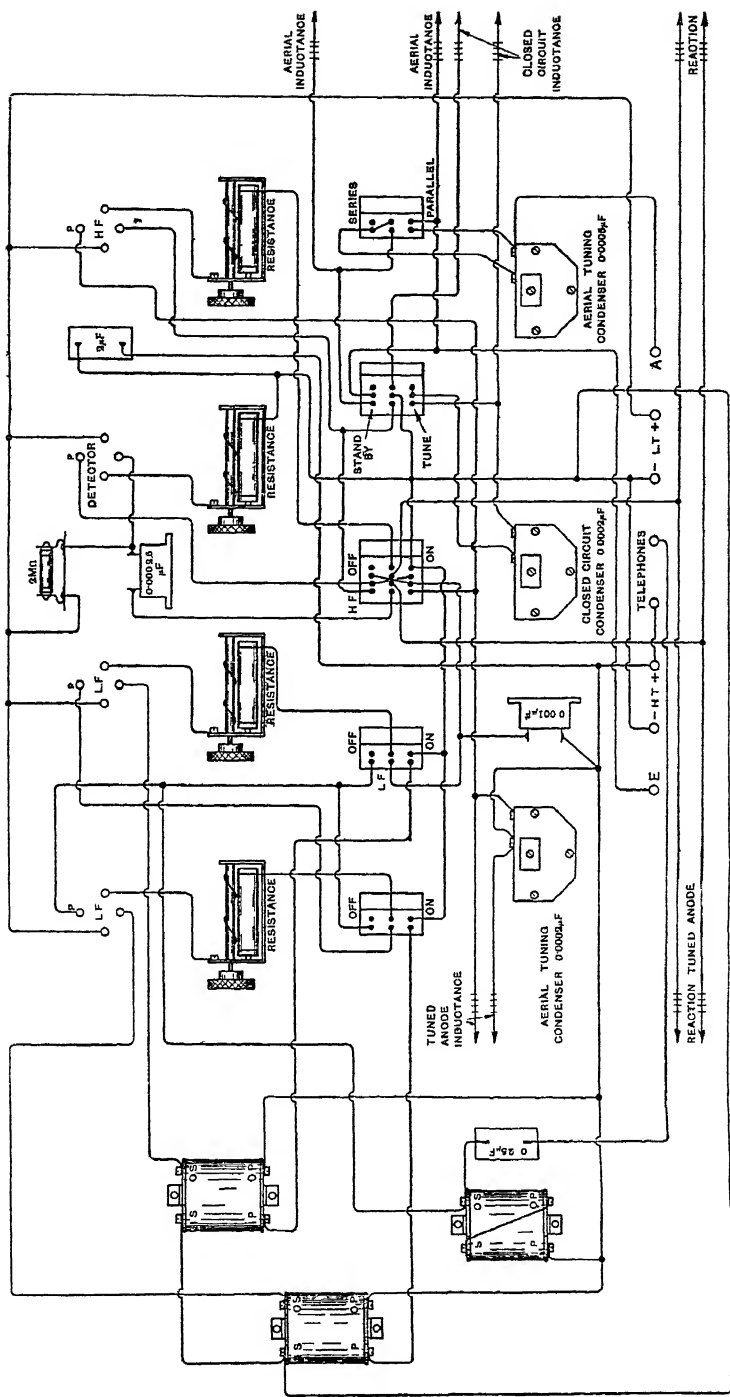
This circuit is given to facilitate the wiring up of the four-valve set shown on the previous page. In a receiver of this sort stiff wiring is essential The long leads should be carried out with No. 16 S.W.G. tinned copper wire straightened by stretching while the shorter branching leads may be of No. 18 S.W.G. The diagram was taken from a receiver and shows the actual points of jointing, though thus may vary somewhat with the design of the set. Leads should be marked off from the diagram as they are fitted.

STANDARD FOUR-VALVE RECEIVER—H.B. 41*
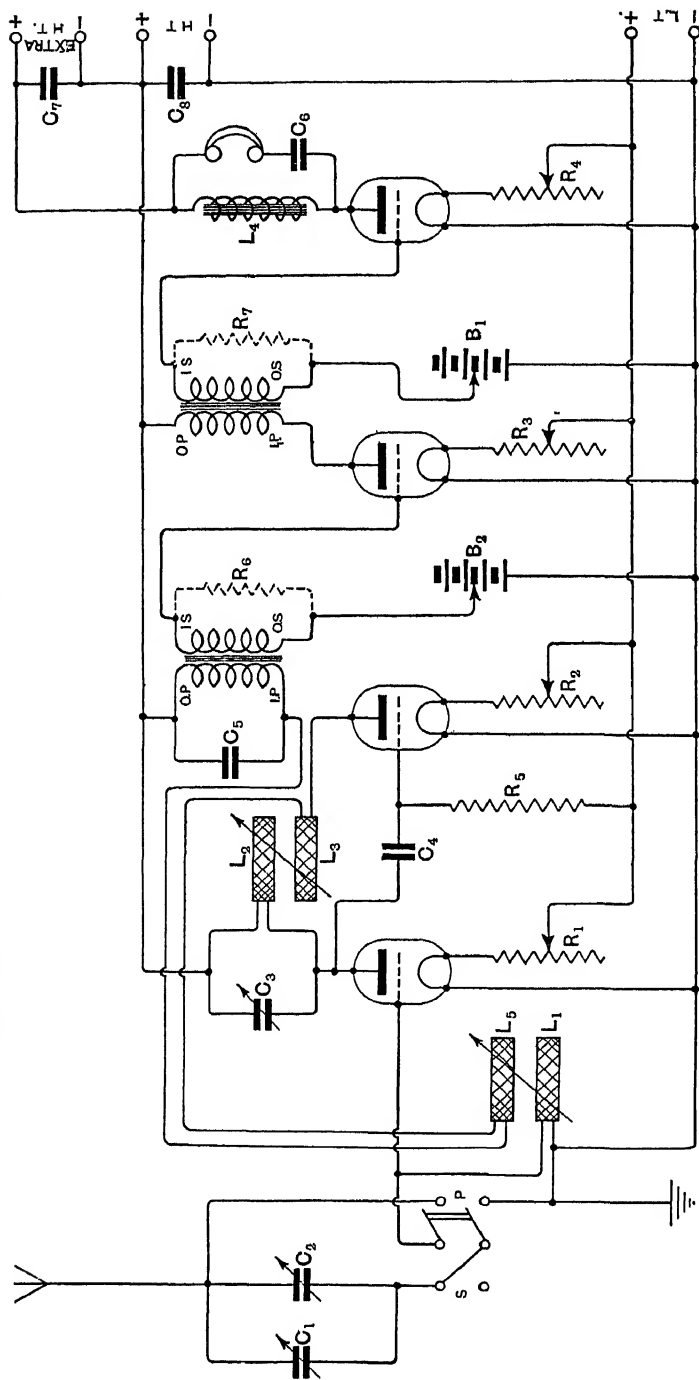
A circuit which can be recommended to have good range with easy manipulation and to give loud speaker signals. C_2, 0·00075 mfds., or 0·001 mfds. with fine adjustment or separate vernier condenser as shown at C_1. C_3 0·003 mfds., which also, with advantage, may be fitted with vernier adjustment C_4 0·00025 mfds. C_5 0·001 mfds. C_6 0·1 or 0·5 mfds. C_7 and C_8, 2 mfds. L_1, L_2, L_3 and L_5, plug-in coils according to wavelength L_4, primary or primary and secondary of a low ratio intervalve transformer. The loud speaker or telephones should be of high resistance R_1, R_2, R_3, R_4, up to 10 ohms for "R" type valves or up to 30 or 40 ohms for filaments taking 0·06 amps. It is recommended that the fourth valve should be a power valve fed from a low ratio intervalve transformer.

TUNED TRANSFORMER H.F. AMPLIFIER—
H.B. 42*
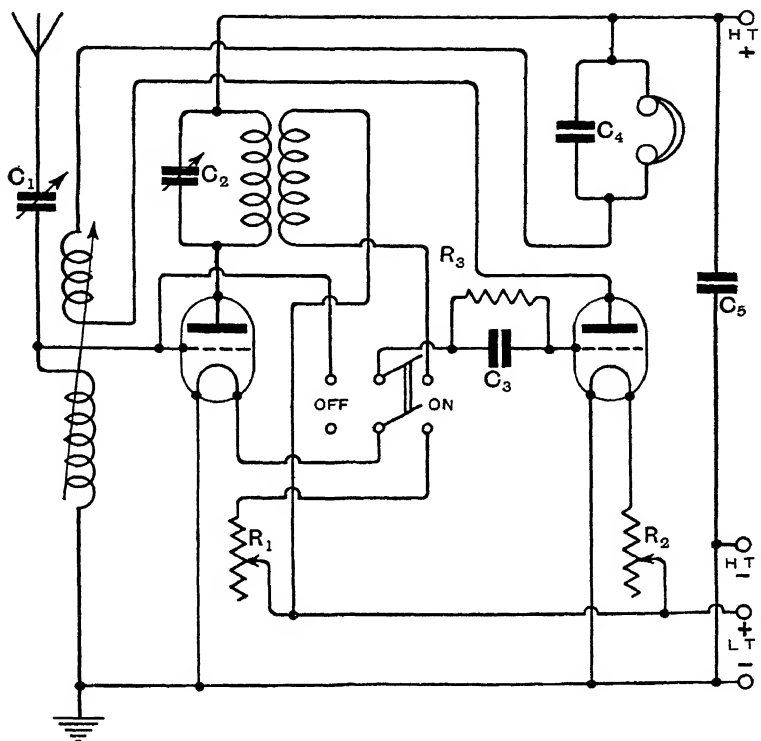
The high frequency amplifying circuits in the foregoing pages operate on the tuned anode principle. In this circuit the tuned transformer arrangement is shown, the merits of which are discussed in the introduction and where constructional details will be found As with the tuned anode it may be helpful to react on to both the transformer windings and the aerial inductance by dividing the reaction coil into two portions connected in series with one another.

The switching of the high frequency amplifier as applied to this type of circuit is included and no loss in efficiency is occasioned by fitting such a switch though the connections must be carried out with stiff wire and well spaced. The components should be so disposed that the leads in the high frequency circuit are as short as possible.

The arrangement of the windings of the transformer should be such that the H T battery end of the primary and the L T battery end of the secondary are adjacent to one another, whilst the direction of the windings should be so arranged that a continuous spool is formed when imagining the battery ends of the windings as being joined together Thus, in winding two single layer coils to form a transformer the wire of the primary may represent a right hand thread and the secondary a left hand thread

When the coupling between the primary and secondary is comparatively loose it is advisable to provide more turns on the secondary and transfer the condenser C_2 so as to bridge its ends The value of C_2 should not exceed o 00025 mfds. on short wavelengths whilst with interchangeable plug-in H.F. transformers a lower value is recommended.

MULTI-STAGE HIGH FREQUENCY AMPLIFIER—H.B. 43
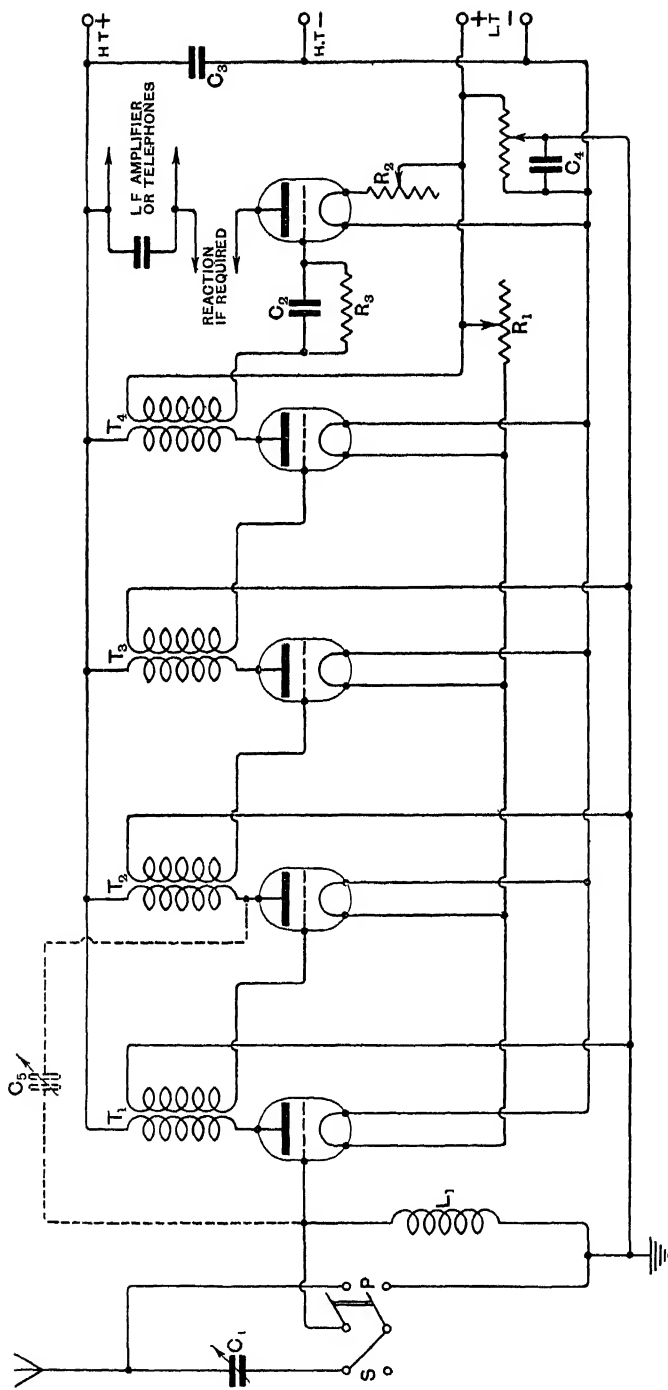
When a considerable degree of high frequency amplification is required it is as well to employ flatly tuned intervalve coupling as it is extremely difficult to tune a number of H.F. valve circuits simultaneously, particularly as oscillation is set up as tuning adjustments are altered. The H.F. transformers may consist of basket coils and each must be carefully tuned on a test circuit by altering the spacing between the two inductances.

The amplification obtainable, with each stage, of this amplifier is not so great as that given by a single tuned stage. The set is particularly suitable for use with a small frame.

Reaction is produced by the 5-plate condenser C_5 which should have a maximum value of about 0·0005 mfds. The wiring up and arrangement of the components of this amplifier must receive careful attention by the constructor to avoid interaction.

H.F. COUPLING WITH TERTIARY TUNING—
H.B. 44
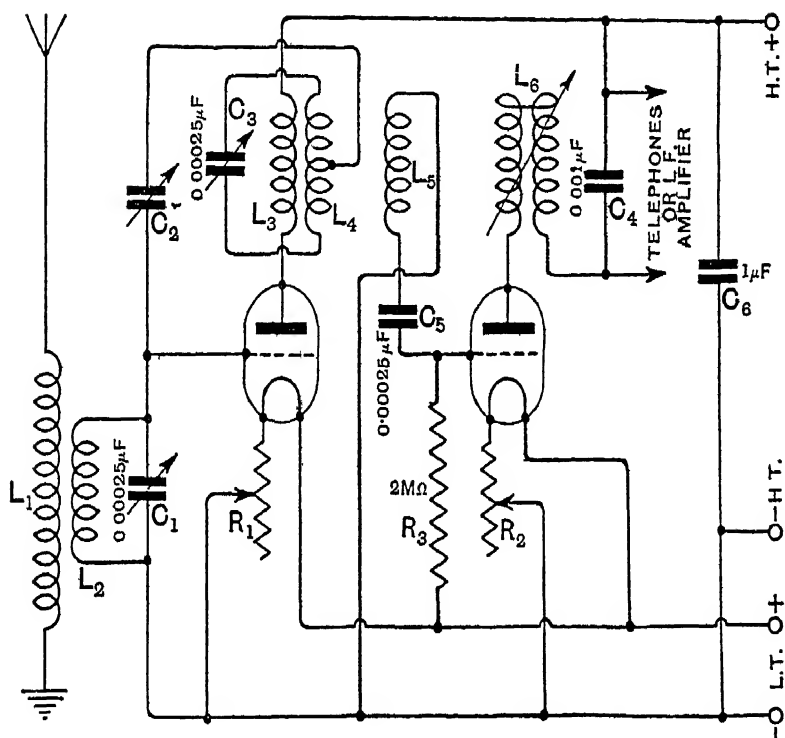
Another method of tuning a high frequency intervalve coupling consists of winding a third inductance over the primary and secondary coils and tuning it with a variable condenser. The three windings may be assembled as basket coils spaced about ⅜" apart. By this form of construction the inductances have reasonably low self-capacity and with moderately loose coupling a potential step-up may be obtained in the grid circuit of the detector valve. Another advantage is that a suitable tapping point can be made on the intermediate tuning inductance for the purpose of feeding back a potential on to the grid circuit to control self-oscillation and stabilise the operation of the set. The condenser C_2 consists of plates about $1'' \times \frac{1}{2}''$ spaced 3/16" apart and made variable by sliding. To allow of the tuning circuits being calibrated it is not possible to bring the reaction inductance alongside the aerial and H F. coupling inductances. Consequently a variometer L_6 has been introduced into the plate circuit of the detector which, when adjusted in conjunction with the condenser C_2 produces critical and constant oscillating effects.

THE NEUTRODYNE ARRANGEMENT—H.B. 45
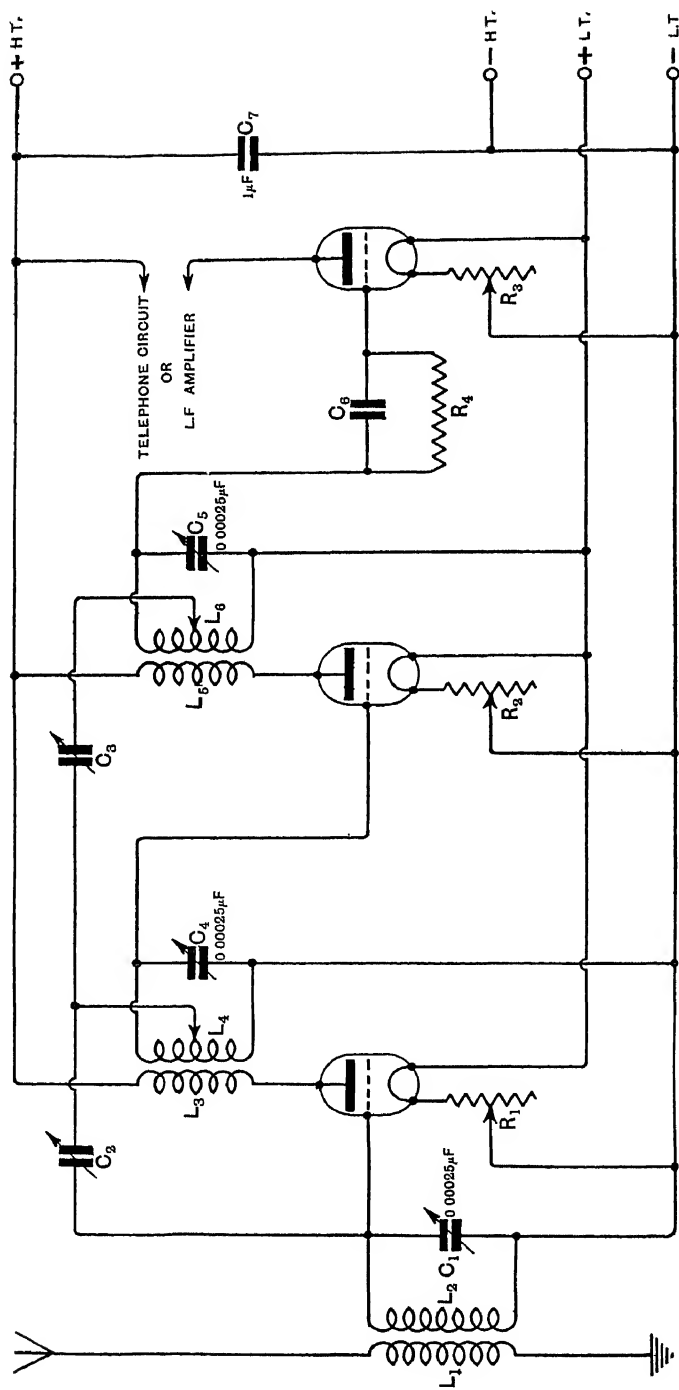
Two stages of tuned high frequency amplification can be manipulated when feed back condensers (C_2 and C_3) are fitted to control self-oscillation The necessary reversal in phase of the potentials fed to the condensers C_2 and C_3 for neutralising valve capacity is obtained by using moderately loosely coupled transformer windings In practice it is not necessary to bridge off the entire secondary winding and a permanent connection can usually be made including only a portion of the turns.

INTERCHANGING H.F. COUPLINGS—H.B. 46
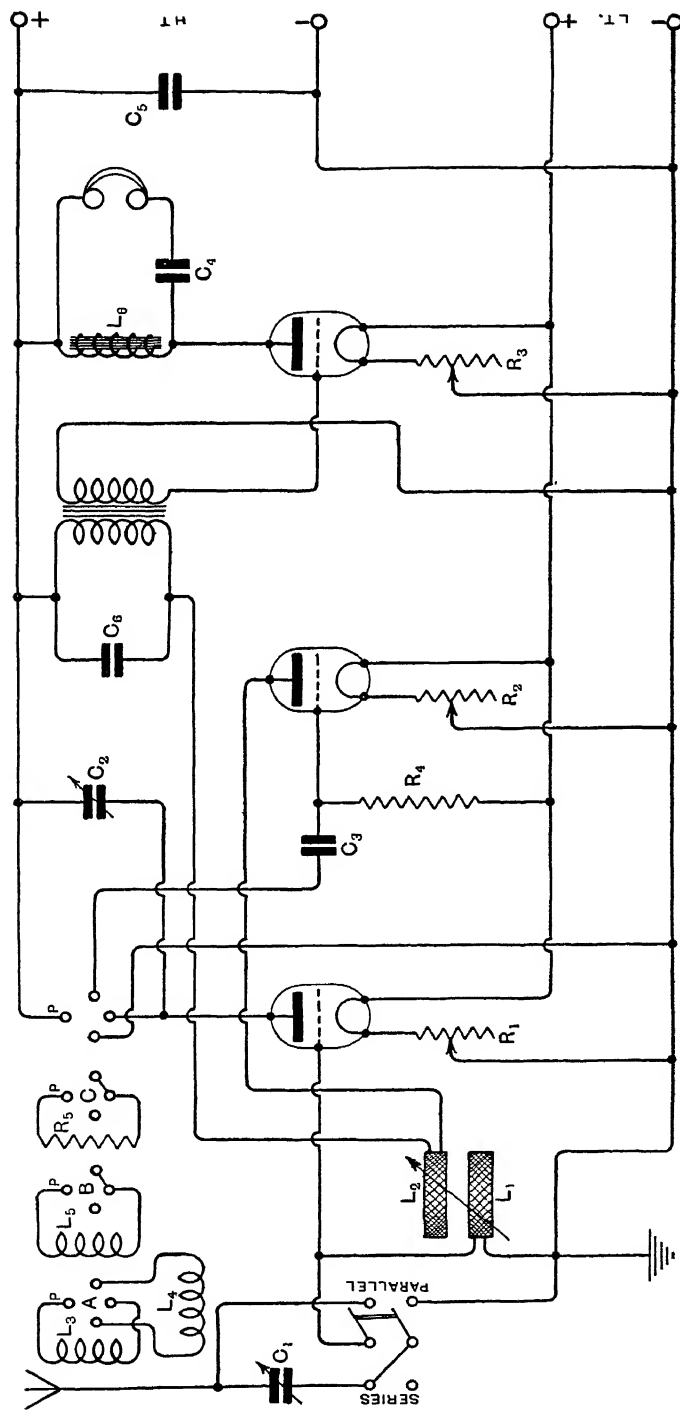
The experimenter who finds it convenient to interchange the various methods of H.F. coupling can fit four valve sockets in the H.F. valve plate circuit for the purpose of plugging in transformer, tuned anode, or resistance coupling units. Various sizes of H.F. transformers fitted with valve pins may be plugged in while small panels fitted with suitably spaced valve pins may carry either tuned anode winding or resistance. For resistance coupling which is used on wavelengths over 1,500 metres, R_5 should have a value between 70,000 and 100,000 ohms. Extra H T. cells should then be introduced in the lead at the top of the diagram which connects the circuits containing the condensers C_3 and C_6. All of the values are given in earlier diagrams.

WITH VARIOMETER TUNING
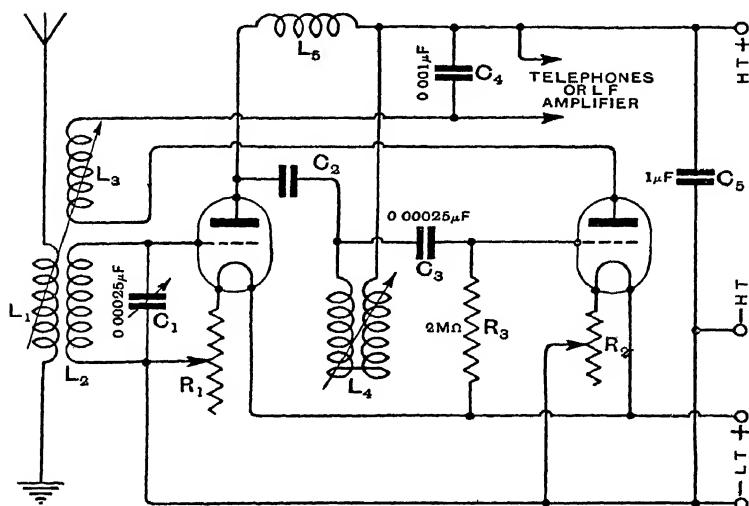
An attempt is made in this circuit to provide a maximum potential transference to the detector valve. The valve anode circuit is tuned by means of the variometer L_4 in conjunction with the condenser C_2 which should have a value of about 0.0001 mfds., for wavelengths up to 450 metres to which this circuit is suited. The efficiency of the circuit depends upon the construction of the choke coil L_5 which must possess an inductance of about 400 mhys and extremely low self-capacity. It may be necessary to change this inductance value on certain wavelengths depending upon the resultant natural wavelengths of the choke coil.

Another somewhat similar circuit consists of connecting the variometer lead to a potentiometer which bridges the L.T. battery, and the grid leak R_3 across the condenser C_3. A small fixed condenser should bridge the potentiometer sliding contact to the L.T. minus.

WITH CLOSED CIRCUIT TUNING
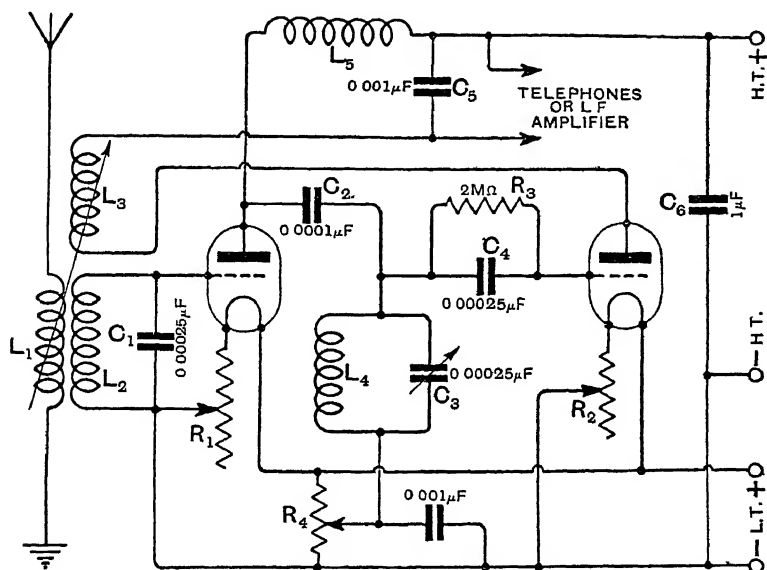
This is a variation of the previous circuit in which a parallel resonance circuit L_4, C_3, is employed for anode tuning in conjunction with the series condenser C_2. Good results can be obtained with this arrangement provided the choke L_5 is carefully designed

In this and the previous diagram the aerial circuit is shown as consisting of coupled inductances   For reception on wavelengths up to 500 metres and using a small amateur aerial it will be found that between 6 and 10 turns 3″ in diameter of No 24 D C C. will be required for the primary and from 25 to 50 turns 2½″ in diameter for the secondary or closed circuit   The spacing between these windings considerably controls the wavelengths to which they will tune by means of the variable condenser C_1. Changes in the position of L_3 also affect the wavelength.

THREE-VALVE RECEIVER FOR SHORT WAVELENGTHS—H.B. 49
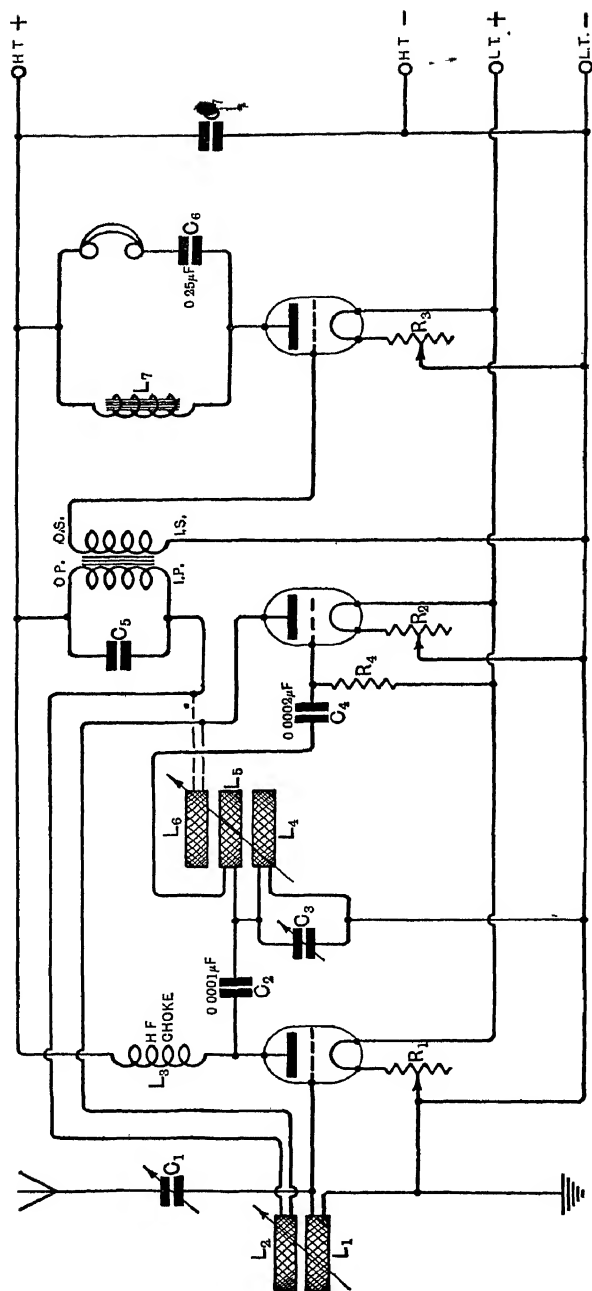
The high frequency amplifying circuit of this three-valve receiver has been designed for working on short wavelengths. The method of feeding the plate current through an H.F. choke L_3, has been shown in previous circuit pages and the special feature here, is that an H.F. transformer is made use of with a series-resonance secondary circuit L_6. The condenser C_2 is common to both the aerial or transformer inductances or both. Methods have already been shown for producing damping in the high frequency amplifying circuit by the use of resistances and may be incorporated here to improve the stability if desired. The efficient working of this circuit depends upon the correct construction of the choke L_3.

60

50

TO AERIAL

PLATE AND H T FEED

L_3

FILAMENT AND EARTH

L_2

L_1

GRID

(a)

51

TO AERIAL

PLATE AND H T FEED

L_3

FILAMENT AND EARTH

L_2

L_1

GRID

(b)

52

TO AERIAL

PLATE AND H T. FEED

L_3

FILAMENT AND EARTH

L_2

L_1

GRID

(c)

53

TO AERIAL

PLATE

L_3

H·T

FILAMENT EARTH AND H·T

L_2

L_1

GRID

(d)
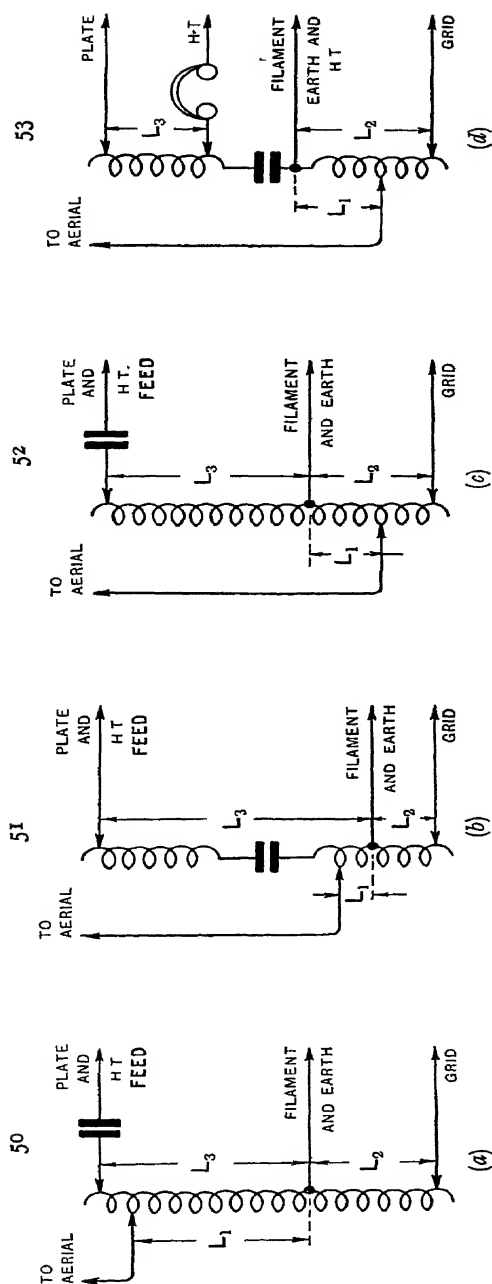
These schematic diagrams show how certain single-coil oscillating circuits are arrived at and in particular a careful study of these diagrams will reveal the operation of the Reinartz circuit which, on first sight, might appear a somewhat confused arrangement. Instead of using separate reaction coil, an extension of the grid circuit tuning inductance will provide the necessary plate circuit coupling, a system which is typical of transmitters. Such an oscillator as shown on the left may be used as a receiver by " auto-coupling " the aerial circuit into the grid or plate inductances as shown respectively in (a) and (c), the latter closely resembling the Reinartz circuit. The condenser shown in each of these diagrams takes the place of the H T. battery and may be introduced into the tuning circuit as in (b) and (d). This brings us to the Reinartz arrangement which is actually represented by (b) though it may be necessary to turn the diagram the other way up to realise that the circuits are identical. When completing circuits (a), (b) and (c) it is necessary to provide an efficient high frequency choke in the high tension lead to the valve plate to prevent oscillation leakage. A correct understanding of these circuits will readily disclose the steps to be taken for the purpose of introducing high frequency amplification into the Reinartz arrangement.

REINARTZ CIRCUIT—H.B. 54,* H.B. 55*

AND METHOD OF ADDING NOTE MAGNIFIER
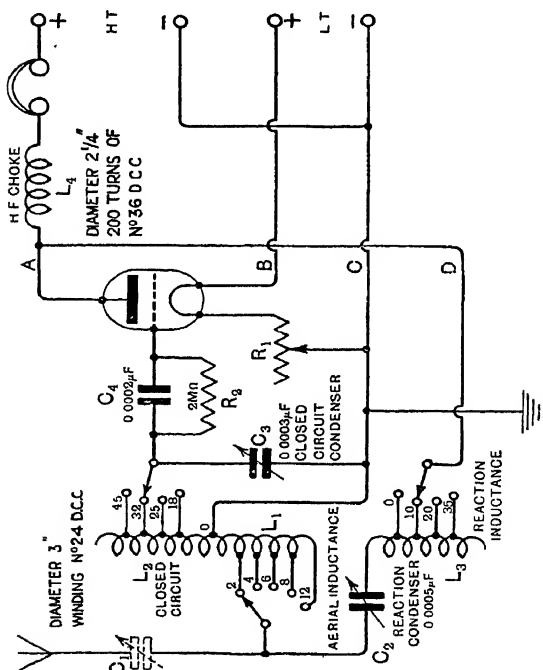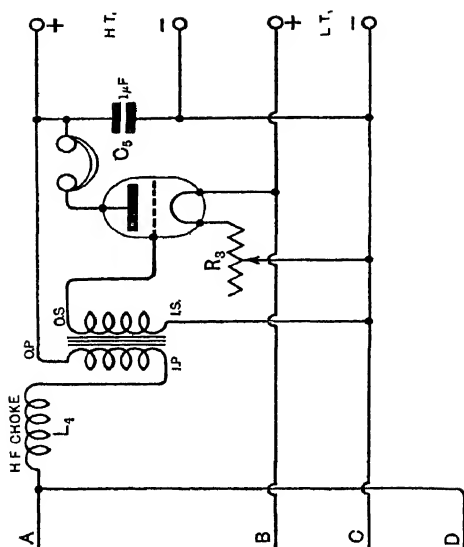
While representing the well-known Reinartz arrangement, this circuit is essentially given for the practical data it contains. The theory of this circuit as an oscillator is explained on a previous page and should be carefully considered in order to understand the tuning operations. The inductances L_1, L_2 and L_3 correspond with those given in (b) of the explanatory diagrams.

No difficulty arises in adding a low frequency amplifier and the complete diagram is produced by overlapping the points A, B, C and D of the two diagrams.

REINARTZ RECEIVER WITH H.F. AMPLIFIER—H.B. 56
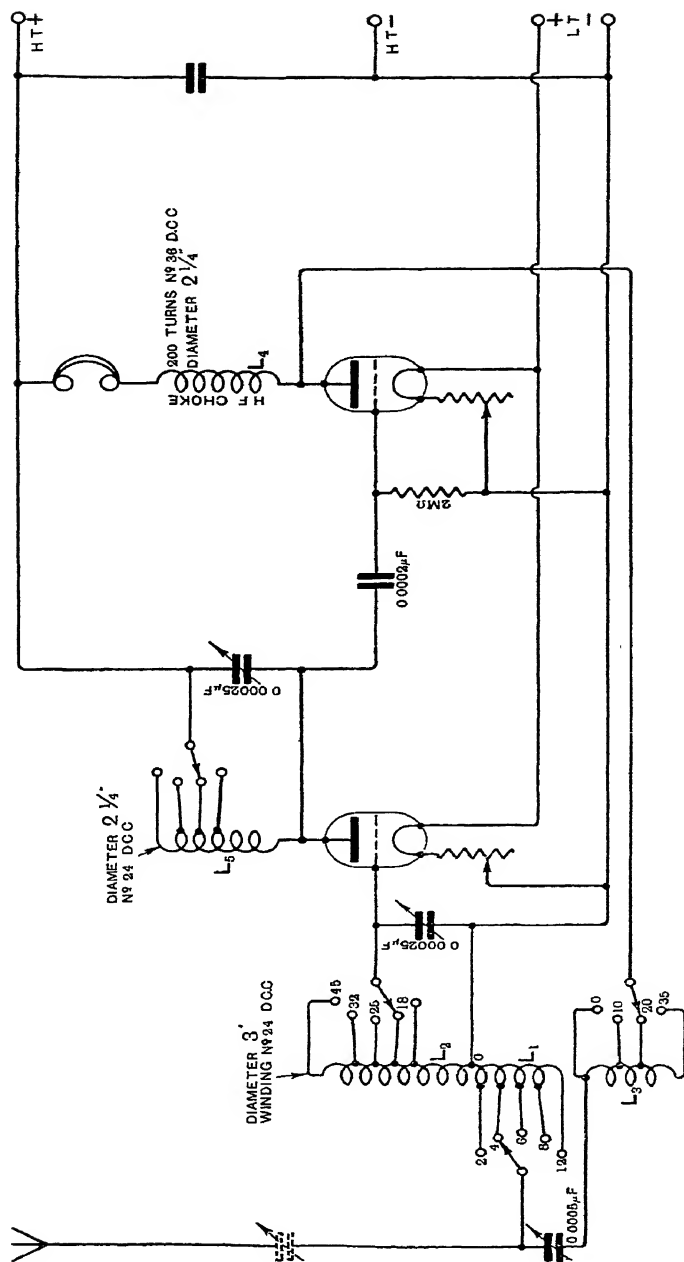
The Reinartz arrangement does not lend itself easily to the introduction of high frequency amplification and as this circuit is essentially required for reception on short wavelengths it is not standard practice to fit a high frequency amplifier.

The circuit shown above, however, is quite satisfactory for use on wavelengths from 190 to 500 metres. The reaction winding L_2 is introduced into the plate circuit of the detector valve. The tapping points on the tuned anode coil L_5 are at the 35th, 45th, 60th and 85th turns.

63
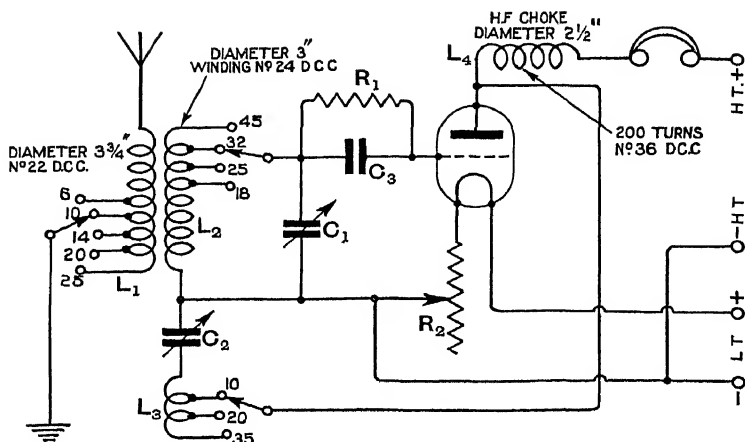
An aerial circuit transformer is here introduced and this arrangement is one of the best for reception on wavelengths of 150 to 400 metres. Details of the inductances are given. Condenser C_1 should have a maximum value of 0·00025 mfds, and for preference should be a square-law condenser with vernier adjustment. The value of C_2 is 0·0005 mfds.
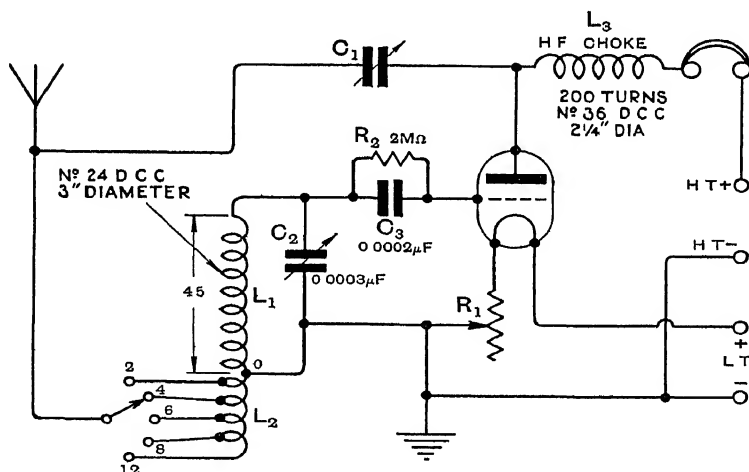
In this circuit the position of the reaction condenser C_1 has been changed so that the inductance L_1, L_2 is continuous. Reference to the explanatory circuits on page 61 will show that this is a straightforward oscillator.
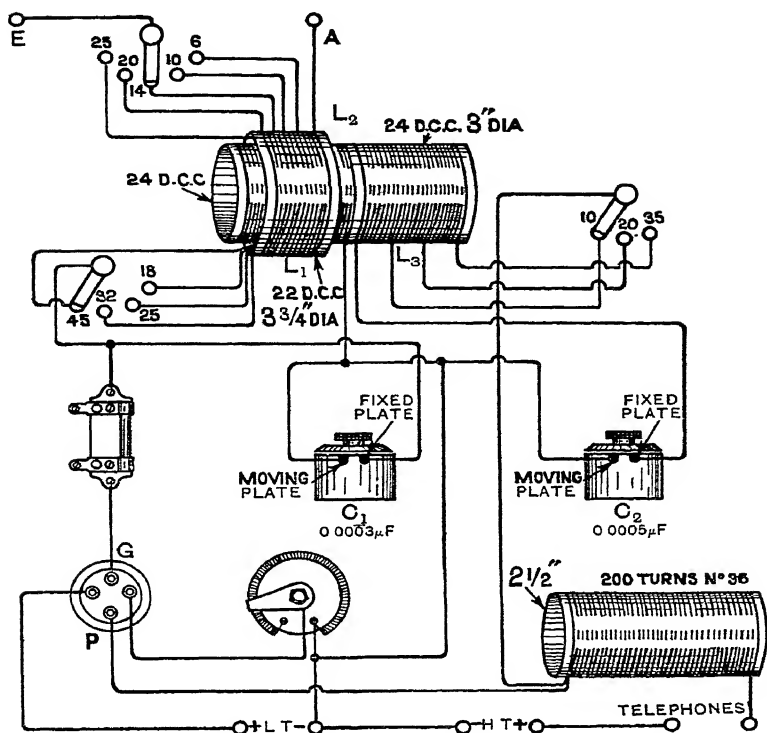
To those inexperienced in the interpretation of circuit diagrams into a practical form this pictorially represented circuit is included. All necessary constructional details are given for the setting up of a Reinartz receiver suitable for wavelengths from 150 to 400 metres when connected to an aerial of the usual dimensions adopted by amateurs. The circuit principle can be examined by reference to the upper figure on the previous page in which the coil and condenser references correspond.

SINGLE VALVE NOTE MAGNIFIER—
H.B. 60* AND H.B. 61*
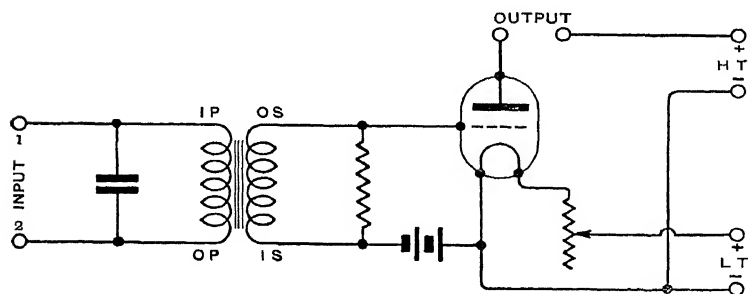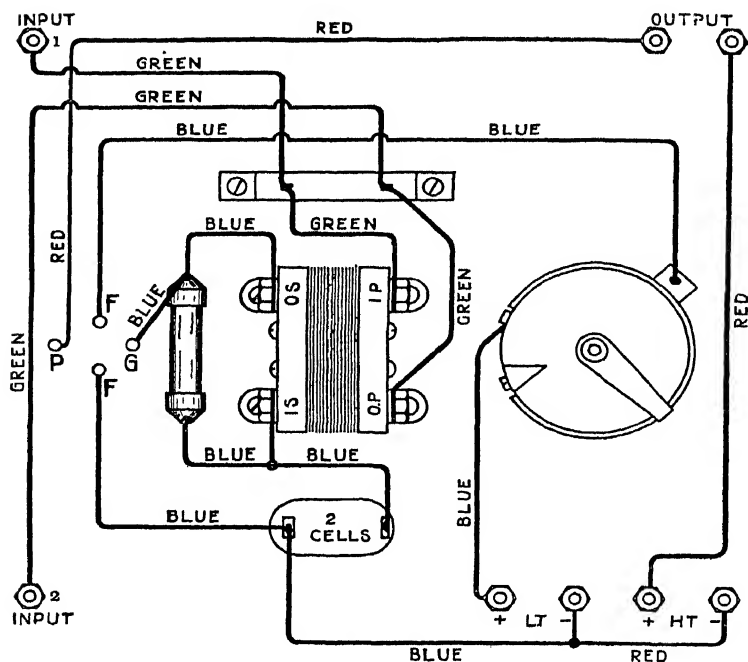
The set circuits show in practical and theoretical form the connecting up of a one valve low frequency amplifier such as would be useful for adding to a crystal or single valve receiver   The filament resistance is connected in the positive lead of the valve so that the grid potential is unaffected by changes in the setting of the filament resistance while the resultant loss of negative potential on the grid is made up by the introduction of two or three small cells   A leak resistance having a value of about 0·5 megohms is connected across the secondary to load the transformer thus producing more even amplification of the various note frequencies.   Connecting up may be carried out with No. 16 S.W.G. tinned copper wire and enamelled in various colours as suggested above

TWO STAGE POWER AMPLIFIER—H.B. 62*

LOUD SPEAKER

INPUT

V₁ V₂ T₁ T₂ T₃ R₁ R₂ R₃ R₄ B₁ B₂ C₁ C₂ C₃ HT LT + —
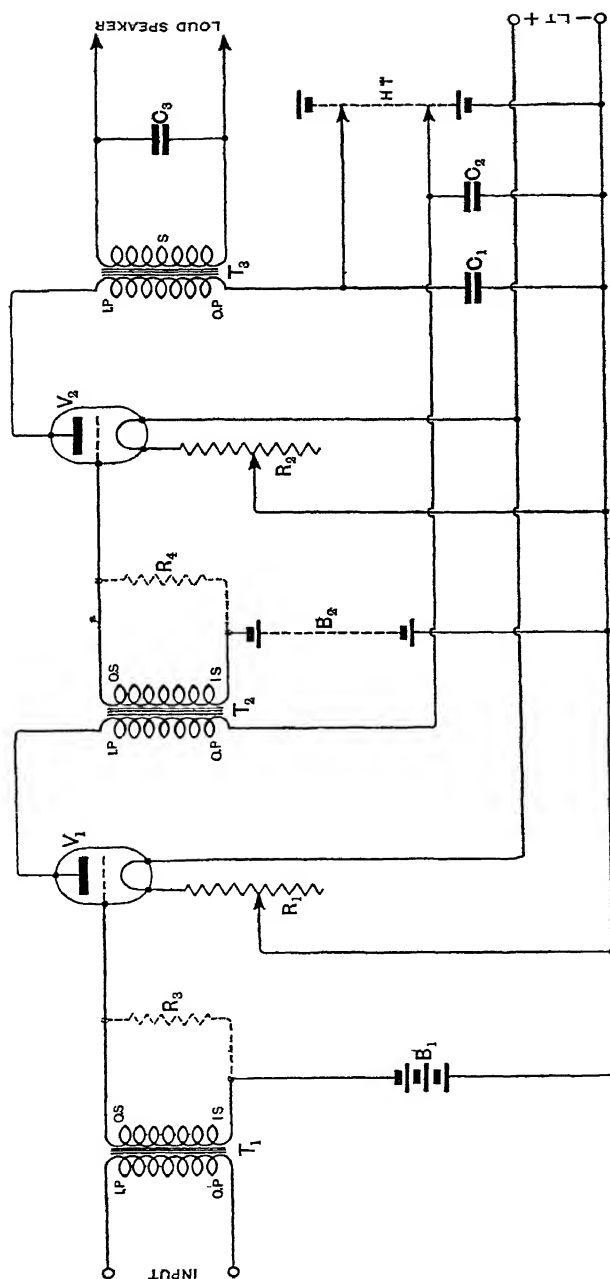
A low frequency amplifier of this type would be added to a high frequency and detector, or detector valve set when it is desired to operate a loud speaker. To reduce the distortion inherent with this type of amplifier, resistances R_3 and R_4 are connected across the transformer secondaries and should have a value of about 0·5 megohms. The values of the grid batteries B_1 and B_2 must be found by test and will depend upon the types of valves used and the voltage of the high tension battery. C_1 and C_2 should be between ½ and 2 microfarads. C_3 is optional and a suitable value can be found by experiment and will depend upon the type of loud speaker and transformer employed. The windings of the intervalve and telephone transformers should suitably match the impedance of the valves, and one is reminded that certain power valves have impedances as low as 8 000 ohms

TWO STAGE POWER AMPLIFIER WITHOUT GRID CELLS—H.B. 63
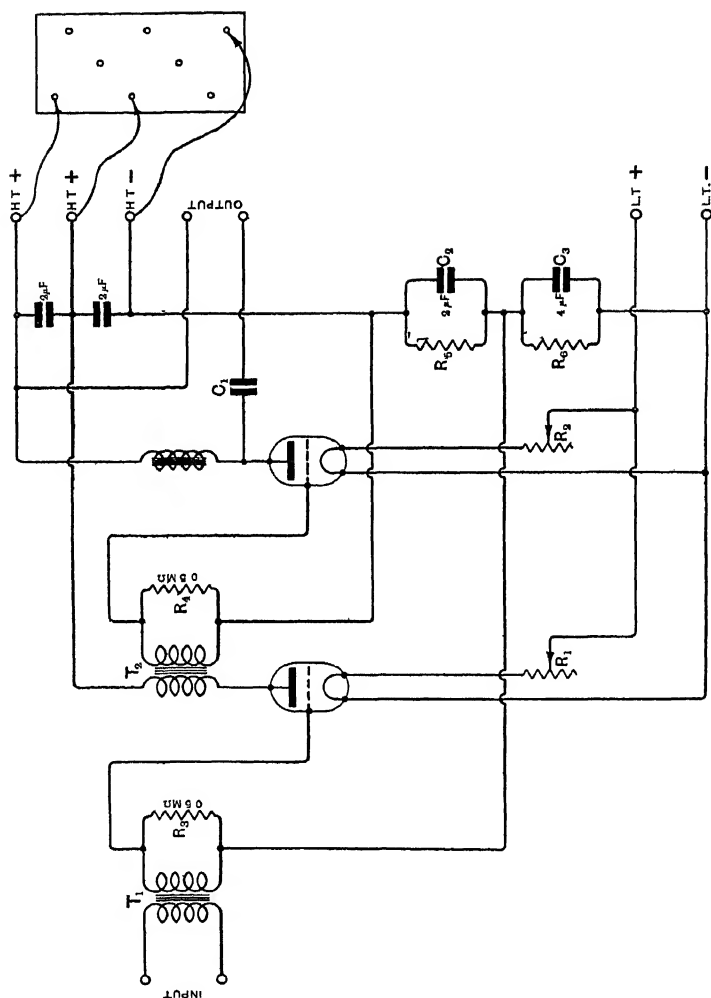
The use of grid cells in receiving apparatus is often considered a disadvantage as they are frequently the cause of noisy amplification and, in any case, they require constant examination and need to be arranged in the receiver in an accessible position. Suitable grid biasing potentials may be set up across resistances connected in the plate circuit and it will be seen that current fluctuations in this circuit produce changes in the biasing grid potentials. To prevent coupling up of the two low frequency amplifiers by the voltage drop across the resistance R, it is necessary to shunt it with a condenser C_3 or, alternatively, the resistance and condenser R_5, C_2, may be connected in circuit with a
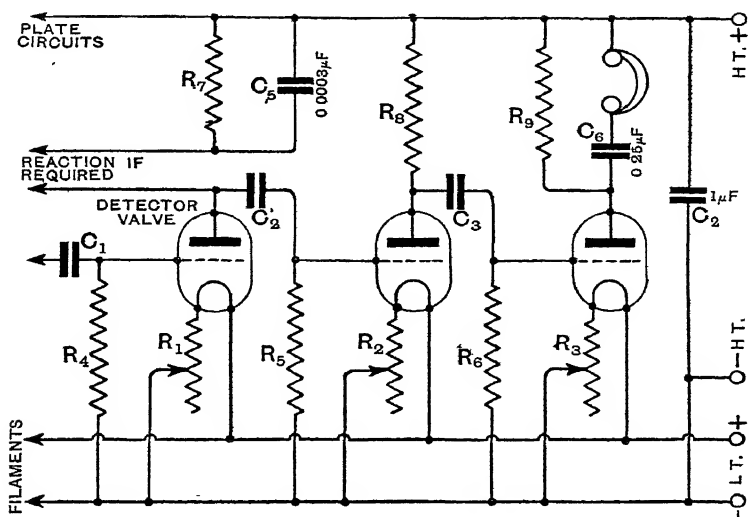
To overcome the defects of uneven amplification of different note frequencies and the consequent distortion which is produced by transformer low frequency coupling the resistance method of amplification is recommended.   The amplification is not so great as is obtained with the transformer method but this may be compensated for by using an additional valve.   The amplifier shown here has only two stages of L.F. amplification but it is quite easy to introduce a third if required.   By operating the valves on the straight part of their characteristic curves, distortion can only be introduced by the uneven reactance of the grid condensers with various note frequencies   If these condensers are made comparatively large, say, greater than 0·1 mfds this effect is insignificant   In practice it is found that a grid condenser value of 0·02 mfds gives best results and mica dielectric condensers are advised   The anode resistances must be capable of passing several milliamperes and the special patterns designed for use with high potentials, some varieties of which are wire wound, must be used.   The resistance R_9 may be substituted by a choke which, though introducing distortion to some degree, does not matter very much as it is not followed by further amplification   The higher the value of the resistances R_7, R_8 and R_9, the greater will be the amplification though, as their values are increased, the H.T voltage will need to be increased also

C_1, 0 00025 mfds. C_2 and C_3, 0 02 mfds R_4, 2 megohms R_5 and R_6, 0 5 megohms R_7, R_8 and R_9, 70,000 to 100,000 ohms

H.F. AND L.F. AMPLIFIER WITH ONE TUNING ADJUSTMENT—**H.B. 65**
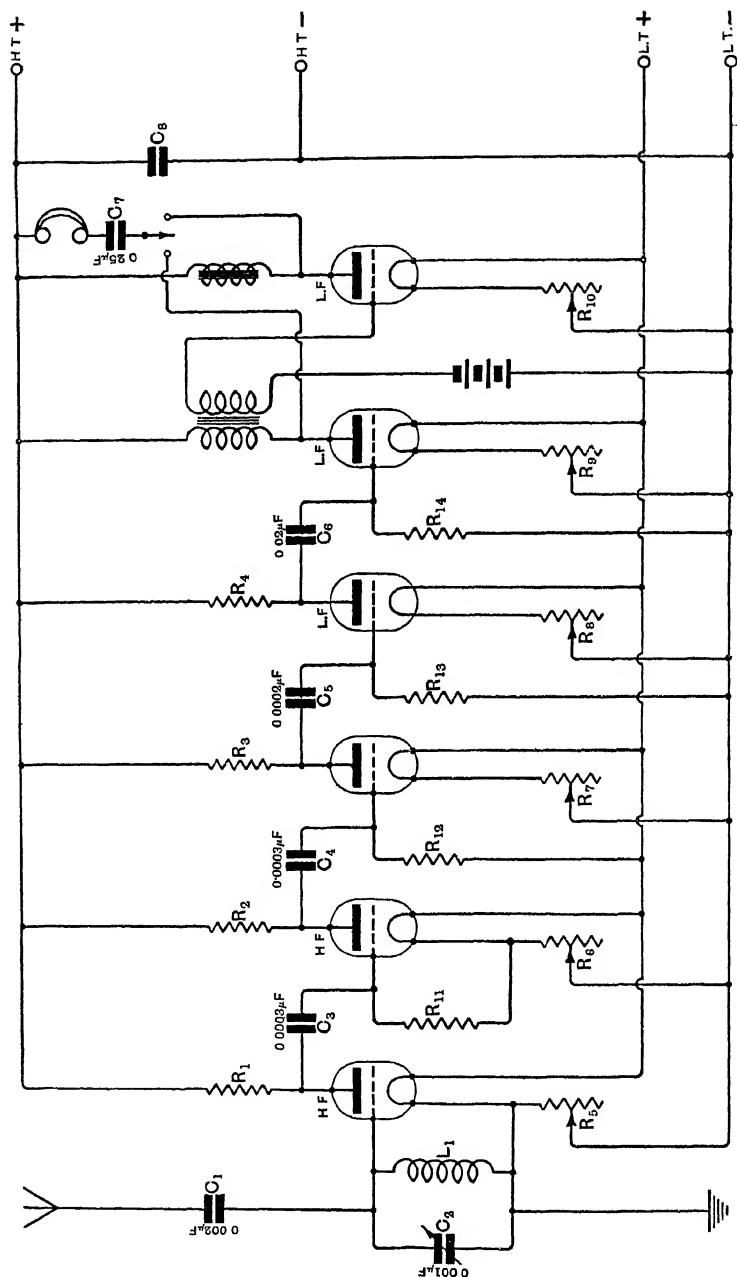
This is a complete receiver designed for telephony reception on wavelengths over 1,500 metres   The series condenser C_1 sharpens the tuning of the aerial circuit and increases the potential delivered by the inductance L_1 to the first valve   The last stage of the L F amplifier is transformer coupled   This will not produce series distortion as no further amplification follows   However, the secondary might be shunted with a leak of about 0 5 megohms as suggested in earlier diagrams   To suit the resistance amplification the voltage of the H T battery is greater than usual and grid cells must be introduced into the grid circuit of the transformer coupled valve   A method of L F valve switching is also shown in this circuit.
   Capacity reaction may be fitted by linking across the grids of the first and third valves with a small variable condenser having a maximum value of 0·00005 mfds
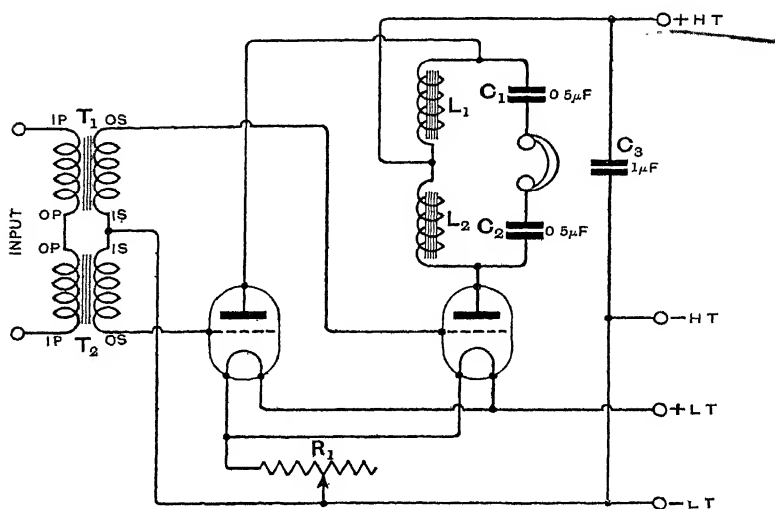R_1, R_2, R_3 and R_4, 100,000 ohms R_{11}, R_{12} and R_{13}, 2 megohms R_{14}, 0 5 megohms
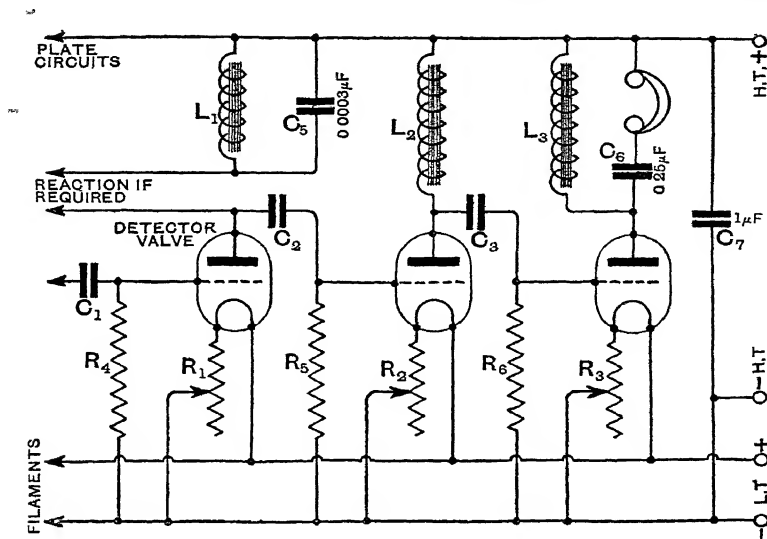
Another method of L.F. coupling consists of connecting highly inductive windings in the plate circuits and feeding the potentials developed across their ends, to the grids of subsequent valves   This method provides for no step-up of potential whilst it possesses all the faults of the transformer system, inasmuch as inductive windings are employed having iron cores.   When a low ratio of intervalve coupling is required, however, there is no objection to using the choke arrangement shown here.   The value of C_5 should be about 0·0003 mfds and C_2 and C_3 0·02 mfds.

"PUSH-PULL" L.F. AMPLIFIER—**H.B. 67**

When special types of power valves are not available for a power amplifier the transformer output may be divided and the fluctuating currents, now at half their normal potential, distributed to two valves. For this circuit it is necessary to employ a transformer having a mid-point tap in the secondary winding, though if this is not available two ordinary intervalve transformers may be connected as shown in this diagram The special merit of the arrangement is that "power" amplification can be obtained without the use of special valves and additional H T. potentials If grid cells are required they should be connected in the lead between the L.T minus and the centre point on the transformer secondaries. The chokes L_1 and L_2 may be intervalve transformers with primaries and secondaries in series while a simpler, and perhaps better arrangement, would be to employ an intervalve power transformer having a ratio of 1 to 1, the mid-point lead being taken to a junction between O.P. and I S.
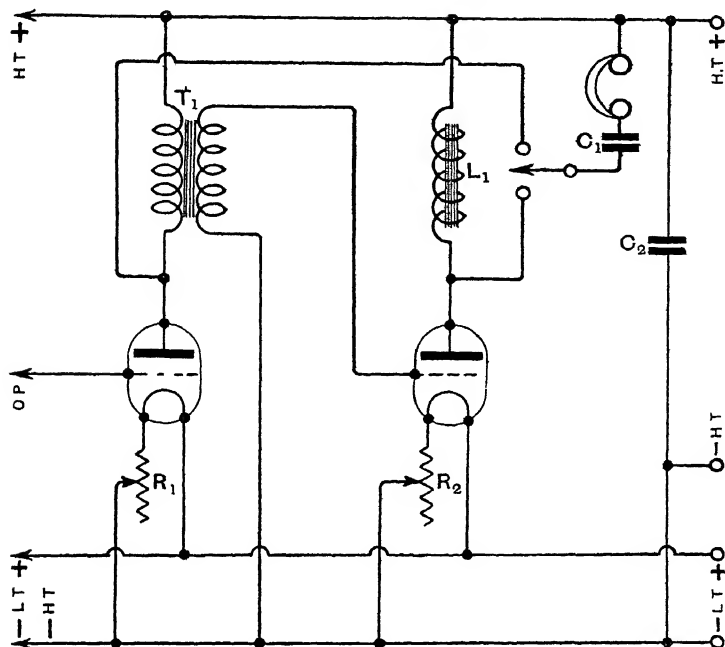
The usual method of switching L.F. amplifying circuits out of use consists of transferring the plate lead of the last valve to an earlier valve and extinguishing the filaments of valves not in use. Another way is shown here which is applicable when a choke is made use of in the last valve circuit for feeding the telephones or loud speaker. By means of a two-way switch the telephone series condenser connection is transferred from the plate of the last valve to that of the previous or earlier valves so that the intervalve transformer primary serves as a low frequency choke.

It may be reiterated here that the telephones or loud speaker connected in series with the condenser should be of high resistance and that this method of feeding the telephones prevents the constant plate current, which may be 10 or more milliamperes in the case of a power amplifying valve, from passing through the telephone windings. The condenser C_1 may have a value between 1/10 and $\frac{1}{2}$ microfarad

73

CONNECTIONS FOR PLUG-IN L.F. UNITS—**H.B. 69**
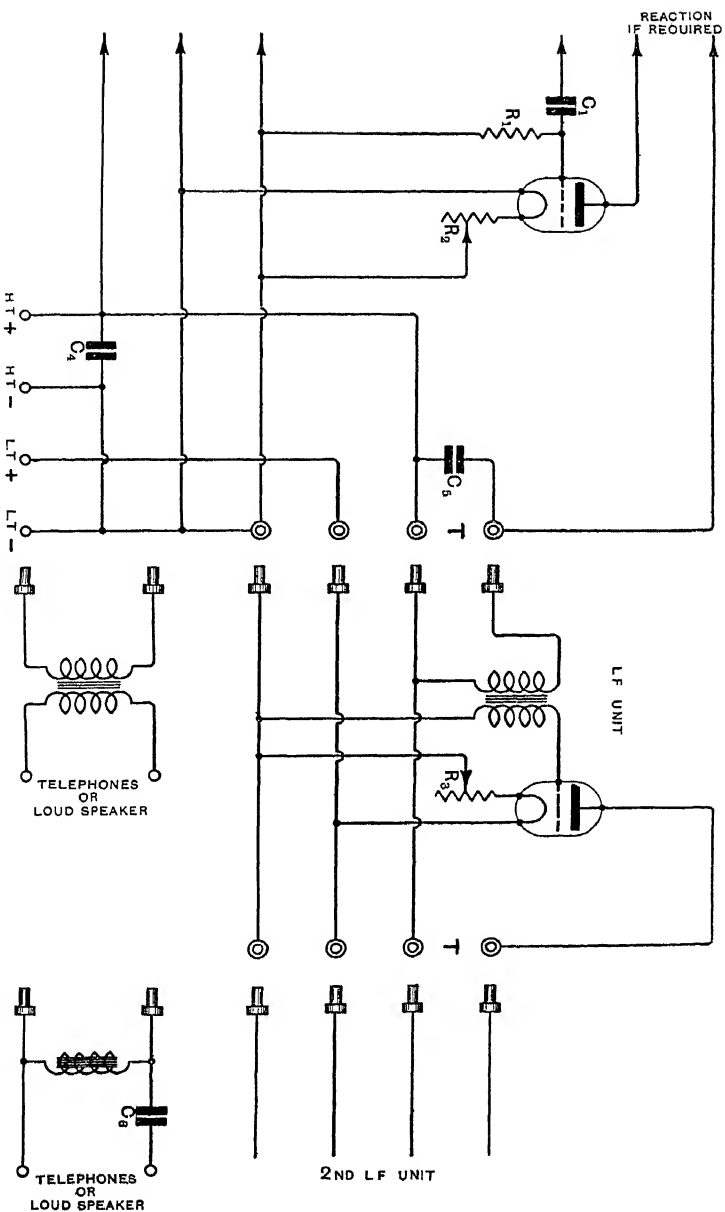
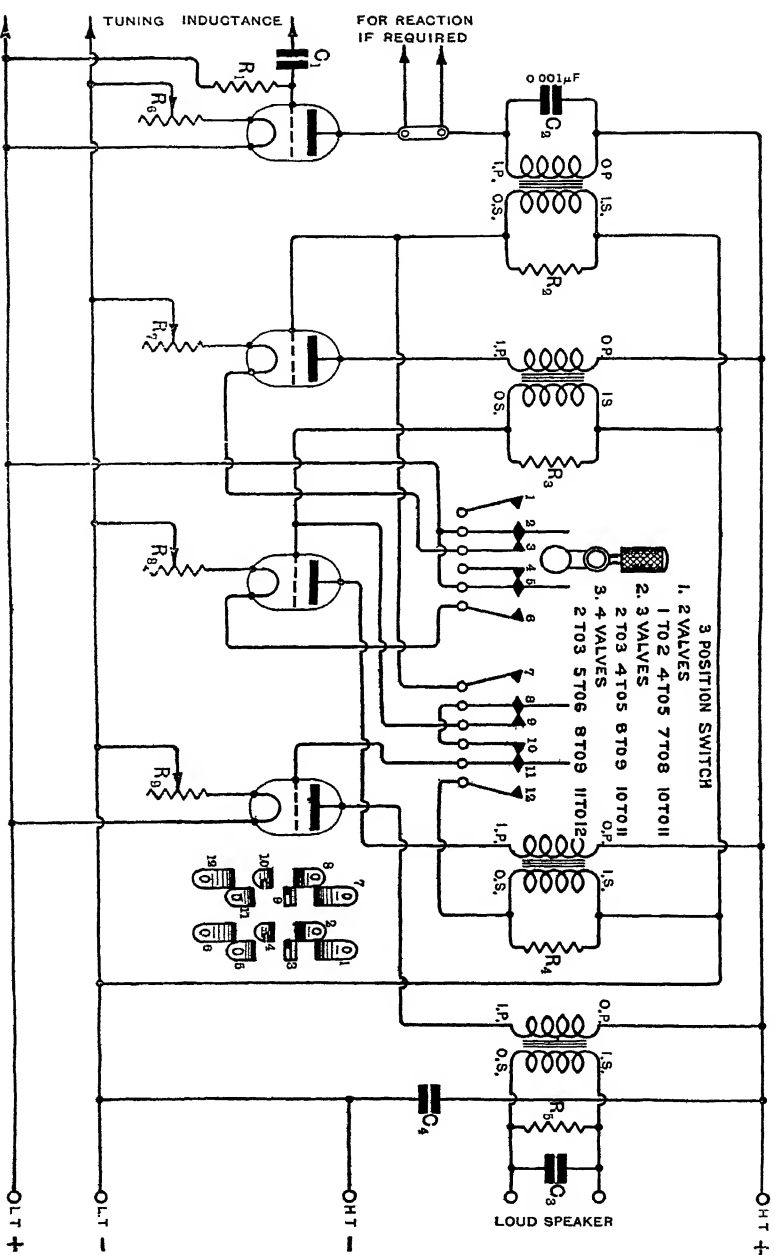This method of removing L.F. amplifying valves from a receiving circuit has often been made use of and units consisting of valve, intervalve transformer and filament resistance are plugged in as required. The system makes no provision for grid biassing and introducing additional H T potential as required though a pair of these units may be found quite useful. The telephones or loud speaker is connected in at the pair of sockets marked "T," or, alternatively, a unit may be made use of consisting either of an intervalve transformer or a feed choke and condenser. In this instance the choke may consist of the primary or primary and secondary connected in series, of an intervalve transformer.

REACTION IF REQUIRED

C_1 R_1 R_2

HT+ HT− LT+ LT−

C_4 C_5 T

TELEPHONES OR LOUD SPEAKER

LF UNIT

R_3 T

2ND LF UNIT

C_8

TELEPHONES OR LOUD SPEAKER

SINGLE KEY SWITCHING OF THREE L.F. VALVES—H.B. 70

TUNING INDUCTANCE

FOR REACTION
IF REQUIRED

C_1

R_1

R_6

0 001μF

C_2

I.P.   I.S.
O.S.

R_2

R_7

I.P.   O.P.
O.S.   I.S.

R_3

R_8

3 POSITION SWITCH

1. 2 VALVES
1 TO 2 4 TO 5 7 TO 8 10 TO 11
2. 3 VALVES
2 TO 3 4 TO 5 8 TO 9 10 TO 11
3. 4 VALVES
2 TO 3 5 TO 6 8 TO 9 11 TO 12

1 2
3
4 5
6

7
8 9
10 11 12

R_9

I.P.   O.P.
O.S.   I.S.

R_4

I.P.   O.P.
O.S.   I.S.

R_5

C_4

C_3

LOUD SPEAKER

○ L.T +

○ L.T −

○ H.T −

○ H.T +

The detector valve and third note magnifier are always in circuit whilst by grid circuit switching one or both of the intermediate valves can be thrown in circuit. A twelve point Dewar type switch is used. The resistances R_2, R_3, R_4 and R_5 are connected across the transformer secondary windings to reduce the distortion inherent with transformer coupling. The value of the condenser C_3 should be found by experiment. Other values will be found in earlier circuits.

KEY SWITCHING OF L.F. VALVE CIRCUITS—H.B.71
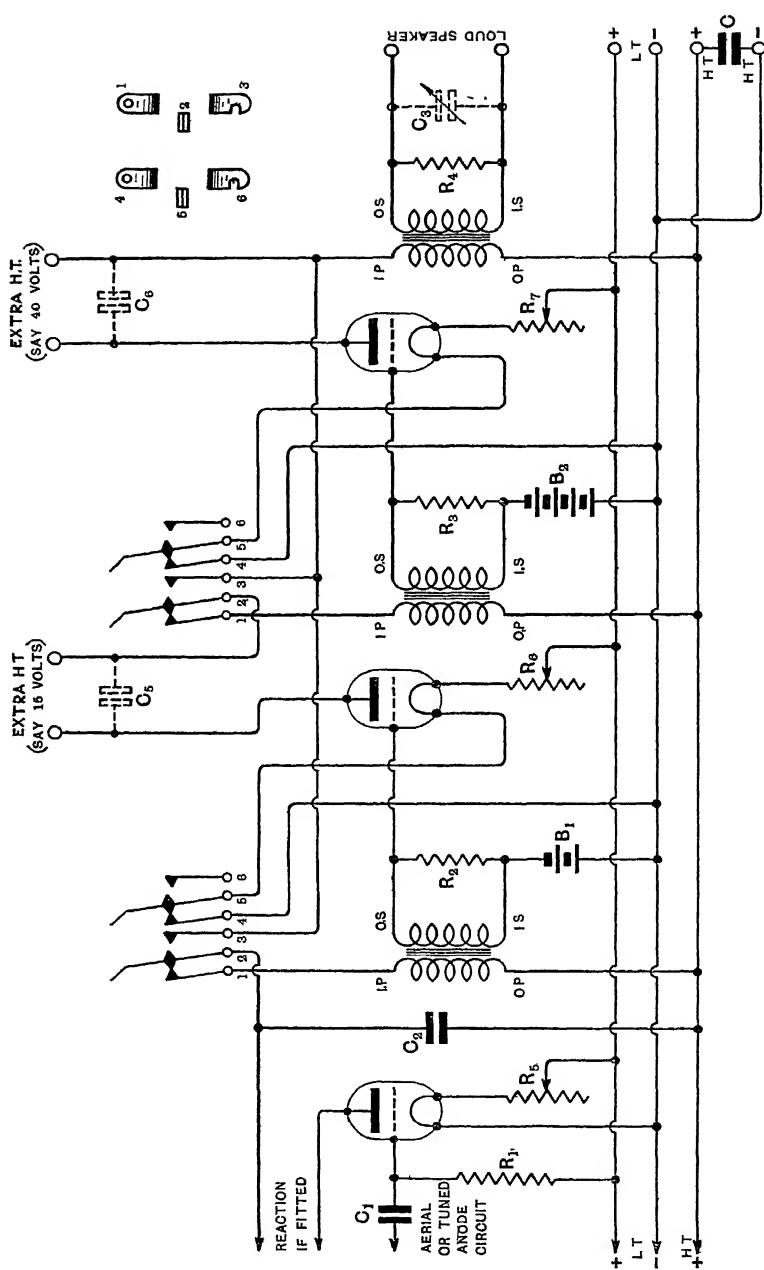
Separate keys are shown here for controlling the L.F valve circuits and are of the two-position type. Grid cells and additional H.T. volts are introduced and suitable values for the batteries B_1 and B_2 must be found by test. The transformer secondary loading resistance may have a value of about 0.5 megohm. The condensers C, C_5 and C_6 have values of between 1 and 2 microfarads.

SINGLE KEY SWITCHING OF TWO L.F. CIRCUITS—H.B. 72

This is quite a good method for switching the valves of a power amplifier out of circuit as required. A single key is used having three positions and it allows for using both note magnifiers or switching one or both out of circuit as required. C_1, o˙ooo2 mfds. C_2, o˙oo1 mfds. C_3, value to be found by experiment depending upon the type of loud speaker employed, and its windings. C_4, C_5 and C_6, 2 mfds. R_1, 2 megohms. R_2, R_3, R_4, o˙1 to o˙5 megohms. R_5, R_6, R_7, values will depend upon types of valves employed. B_1 and B_2, cells as shown, though some variation from these values may be necessary and can be found by test.

FOUR VALVE RECEIVER WITH KEY L.F. SWITCHING—H.B. 73
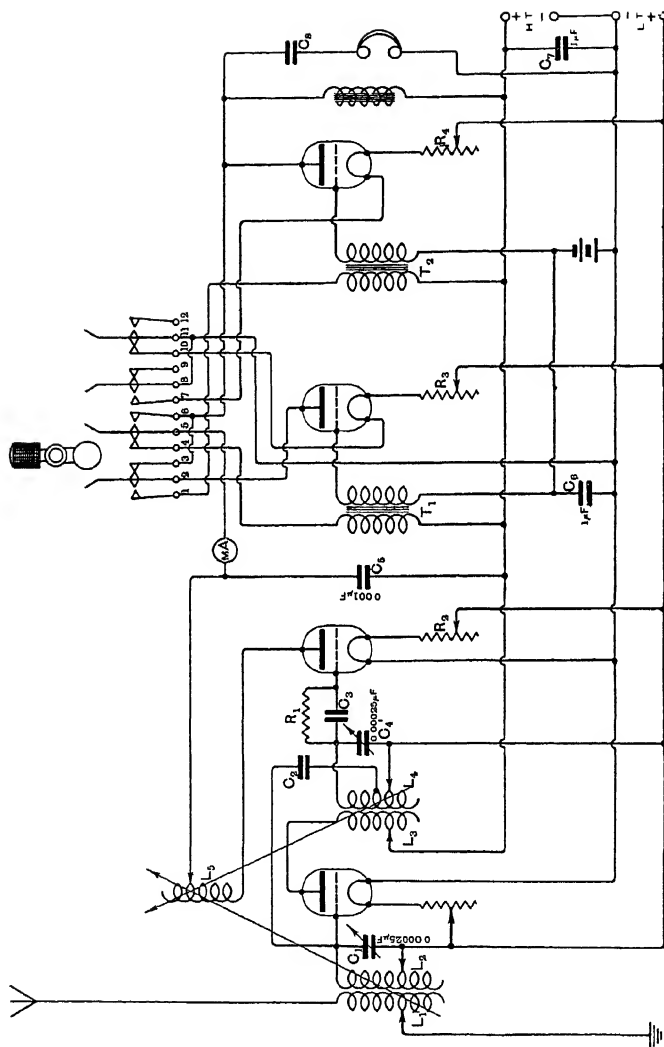
A single twelve-point Dewar switch is arranged to throw in or out of circuit either, or both of the two L.F valves.   As the filament resistances R_3 and R_4 are in the positive battery leads it is necessary to introduce one or two grid cells to restore a suitable negative potential on the grids of the note magnifiers.   The H.F and detector valves are in a typical circuit such as already described and the neutralising condenser C_2 has been referred to in the neutrodyne circuit   With most valves it will probably be necessary to connect the lower end of the closed circuit to the filament minus instead of the filament plus as shown whilst the lead from the point C_4 to the filament may often, with advantage, be connected to a potentiometer as shown in earlier circuits.

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# FOUR VALVE RECEIVER SHOWING L.F. SWITCHING USING BREAK JACKS—

H.B. 74*
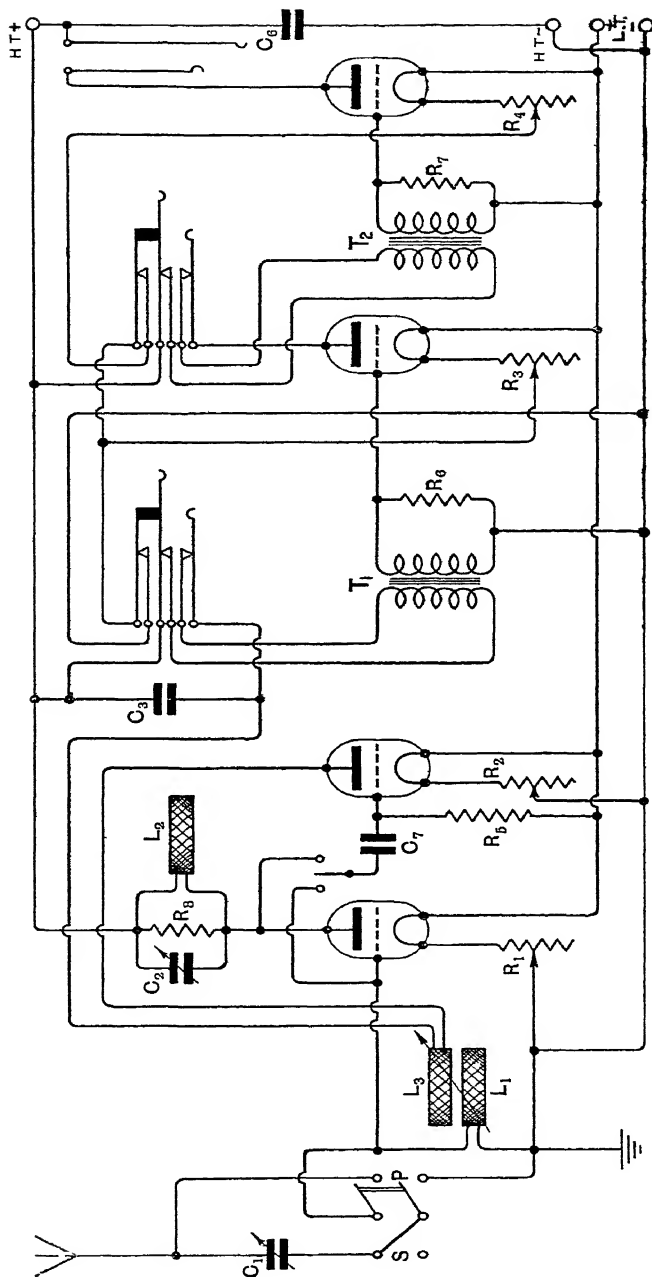
The switching of L.F. valves out of circuit by means of break jacks is an exceedingly neat arrangement. Very little panel space is taken up by the jacks and it is only necessary to plug in to the position giving the desired amplification. The type of jack shown is a well-known pattern and is easily obtainable. The H.F. amplifier may be thrown out of circuit by means of a two-position switch and the resistance R_1 must have an "off" position

This is a good standard four-valve circuit   The resistance R_8 is optional and all other values can be found in earlier circuits.

SINGLE VALVE SERIES DUAL AMPLIFIER—
## H.B. 75

WITH CRYSTAL DETECTOR
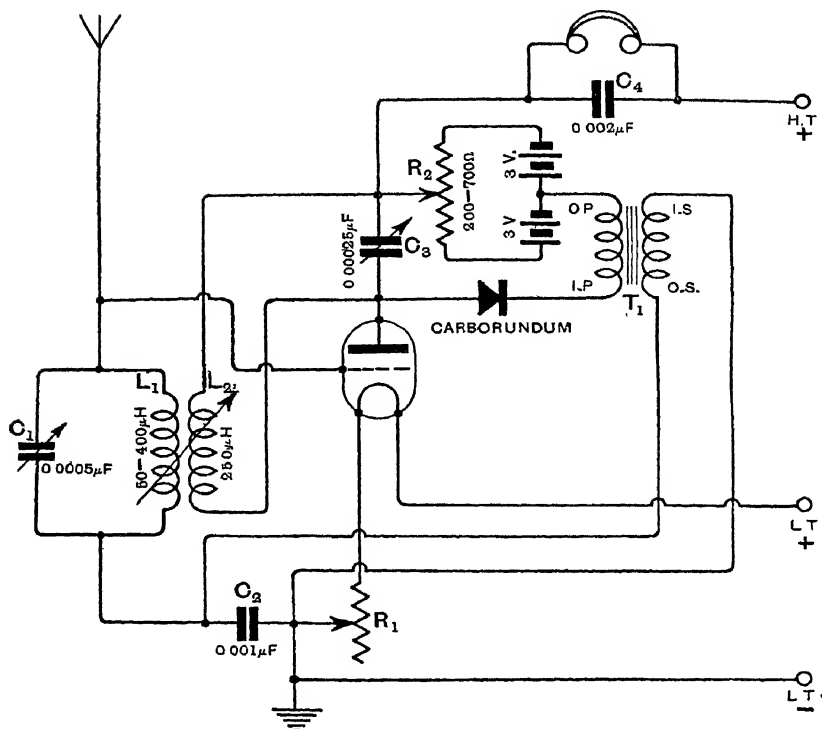
This is one of the simplest of dual amplification circuits. The aerial may be tuned either with a series or parallel condenser, the former being more selective than the latter and producing greater signal strength on short wavelengths, though rather erratic as regards self-oscillation. High frequency amplification is obtained by a tuned anode circuit which is shown variably coupled to the aerial circuit to stimulate some degree of oscillation if desired and to allow for the damping produced by the crystal and L F transformer which are connected across the tuned anode circuit. Any type of crystal detector may be used though carborundum is particularly stable, a useful property when connected directly to a high voltage circuit. The potentiometer and battery are only needed when a carborundum detector is employed.

It will be observed that the low frequency transformer secondary is virtually in the aerial circuit. Were the earth connection taken from the lower end of the aerial tuned circuit the transformer secondary would then be short circuited by the high capacity or low insulation which the filament or H.T. batteries may have to earth. The H.T. negative lead is connected to the L.T. negative terminal or earth. The reader is referred to the preliminary pages of this book for further details concerning the operation of this circuit.

SINGLE VALVE LOOSE COUPLED
## DUAL CIRCUIT—**H.B. 76**

WITH CRYSTAL DETECTOR
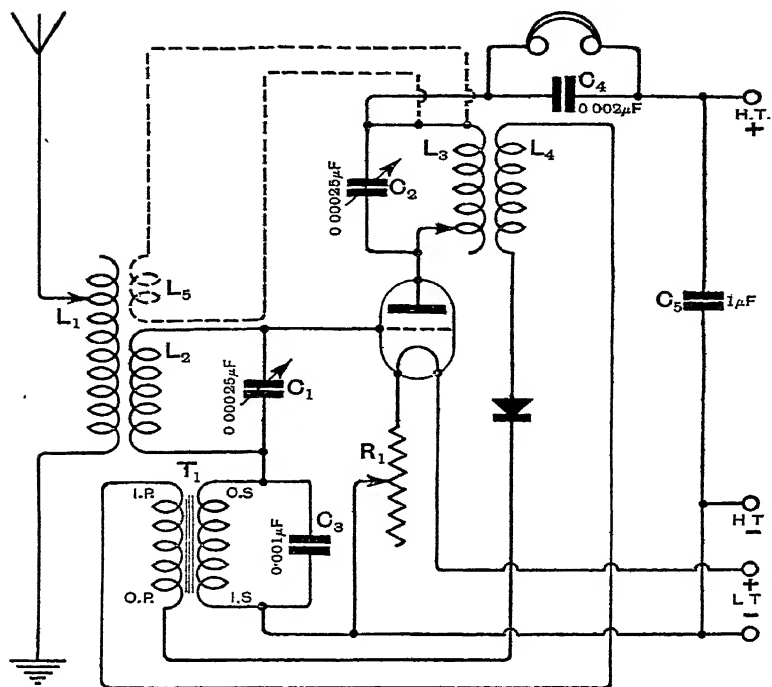
A loose coupled aerial circuit is introduced here whilst loose coupling is also provided between the tuned anode and detector circuit to isolate the crystal from direct current potentials which may be applied to it when the apparatus in the circuit is handled. If variable reaction is desired it may be introduced as shown at L_5.
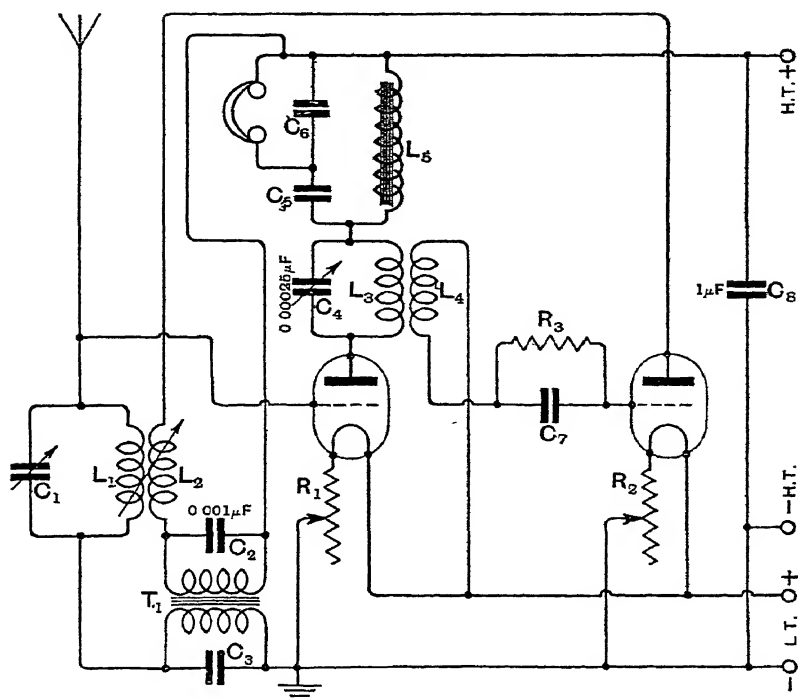
F
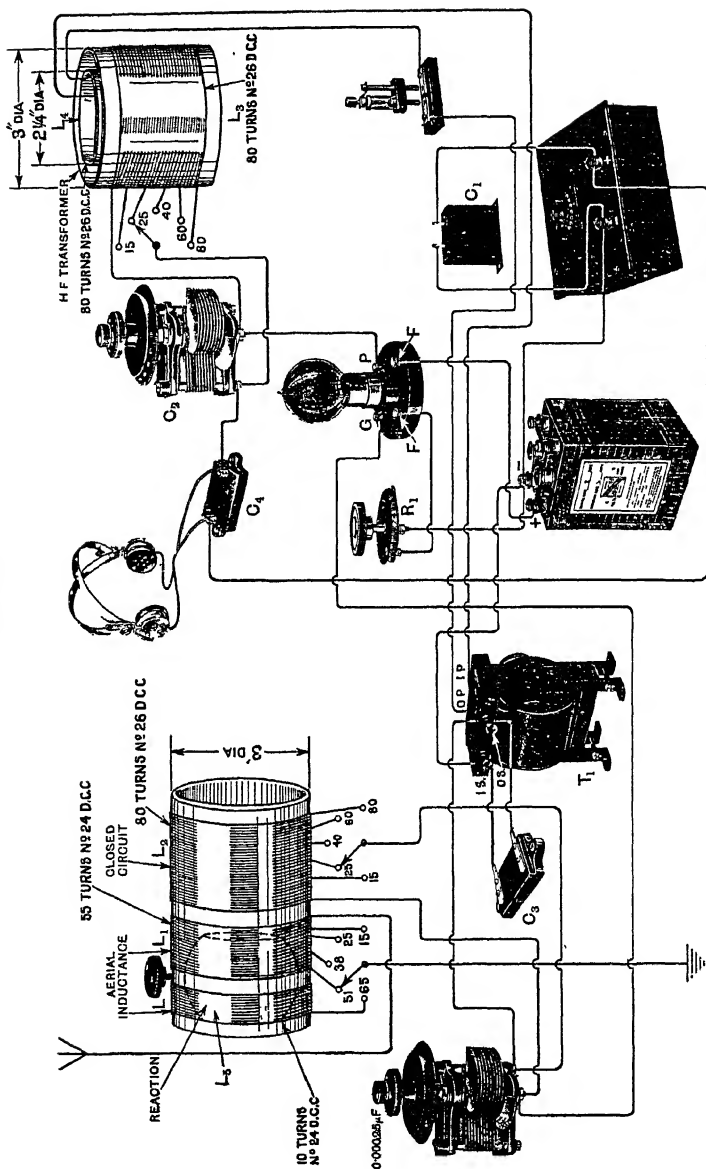
WITH VALVE DETECTOR

A valve detector is substituted here for the crystal shown in the previous diagrams. The valve detector is recommended when filament current is not a consideration or when dull emitter valves are available The telephone receivers may if desired, be connected in the H T lead though by connecting them as shown the passing of constant plate current through them is avoided   The telephones should be of the H.R. type while condenser C_5 should have a value of about o 25 mfds and the value of C_6, if used at all, may be found by experiment   Its capacity will be somewhere about o oo2 mfds.

PARALLEL DUAL CIRCUIT—H.B. 79

WITH VALVE DETECTOR
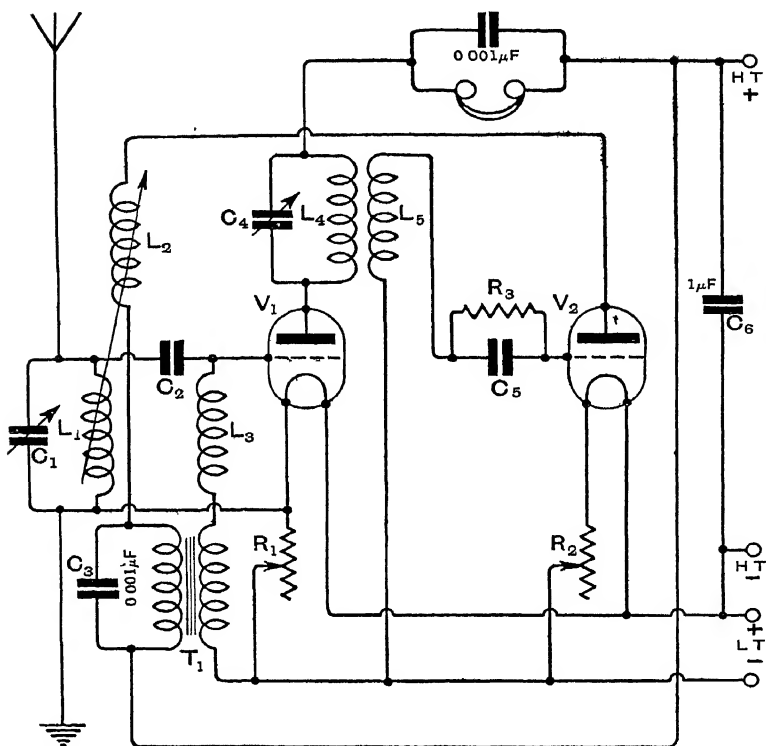
The low frequency feed back circuit is here arranged in parallel with the aerial tuning circuit. To prevent short circuiting of the aerial high frequency circuit by the capacity of the transformer windings a high frequency choke L_3 is introduced. The correct operation of this circuit depends essentially on the efficient construction of this choke which must be wound to have low self-capacity. Three spaced basket coils wound with No 30 D S C. of a mean diameter of about $2\frac{1}{2}''$ and, when connected in series, making approximately 200 turns forms a satisfactory high frequency choke for use on wavelengths up to 800 metres. On longer wavelengths the leakage due to the capacity of the winding is not so great and as a larger inductance is required a suitable plug-in coil may be used. The condenser C_2 has a value of about 0·0001 mfds , thus having a high reactance to currents at speech frequency and preventing the aerial tuning inductance from short circuiting the transformer secondary. L_2 is a reaction coil coupled to the aerial circuit and provision may also be made, if desired, for reacting on to the high frequency transformer L_4, L_5. The high frequency transformer may easily be substituted by tuned anode by connecting the grid condenser C_5 to the plate of V_1 and the leak resistance R_3 to the L.T. plus or potentiometer slider, if fitted.

DUAL AMPLIFICATION CIRCUIT WITH VALVE DETECTOR AND NOTE MAGNIFIER—H.B.80

This circuit does not greatly differ from the preceding ones except that a note magnifier is added and the aerial tuning condenser is arranged in series with the aerial inductance The merits of this arrangement have been referred to earlier. L_2 is the reaction coil coupled with the anode inductance L_3. If L_1, L_2, and L_3 are inductances of the plug-in type, the reaction coil may be fitted in the centre of the coil holder so that it may influence both aerial and tuned anode circuits

For power amplification the telephones and choke L_4 may be joined to the lead providing additional H.T. potential and grid cells introduced as shown.

NEUTRODYNE H.F. CIRCUIT WITH DUAL AMPLIFICATION—H.B. 81
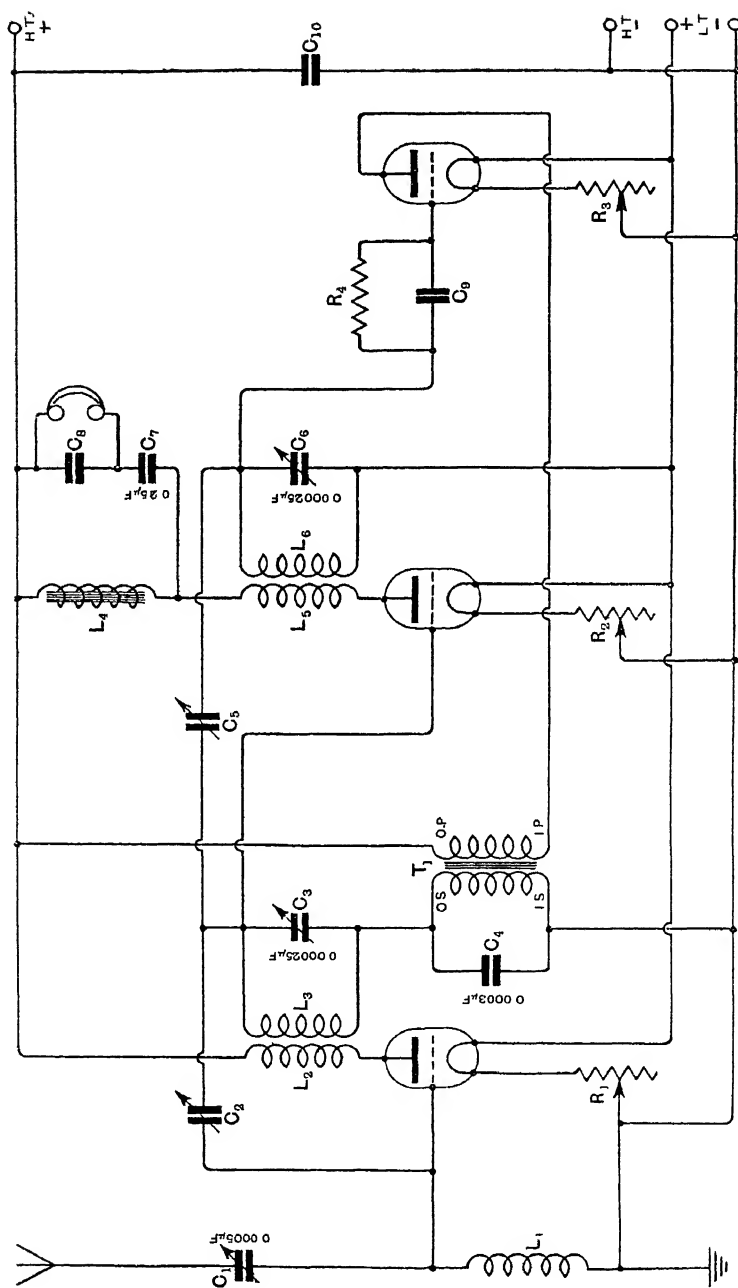
It is sometimes desirable to fit an additional high frequency amplifying circuit in front of a dual arrangement to make up for the loss of efficiency which often occurs in a dualled high frequency amplifier. In this circuit the first high frequency amplifier is not dualled and to facilitate the tuning of two high frequency circuits, condensers C_2 and C_5 are fitted to prevent self-oscillation due to valve capacity. Construction data will be found in the preliminary and earlier circuit pages.
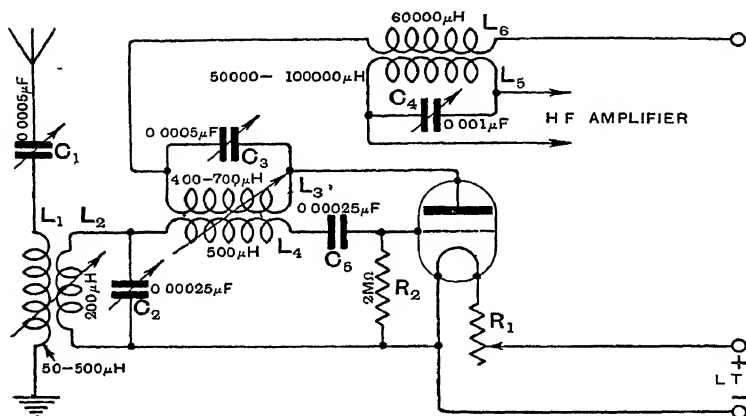
SUPERSONIC HETERODYNE RECEIVER—H.B. 82
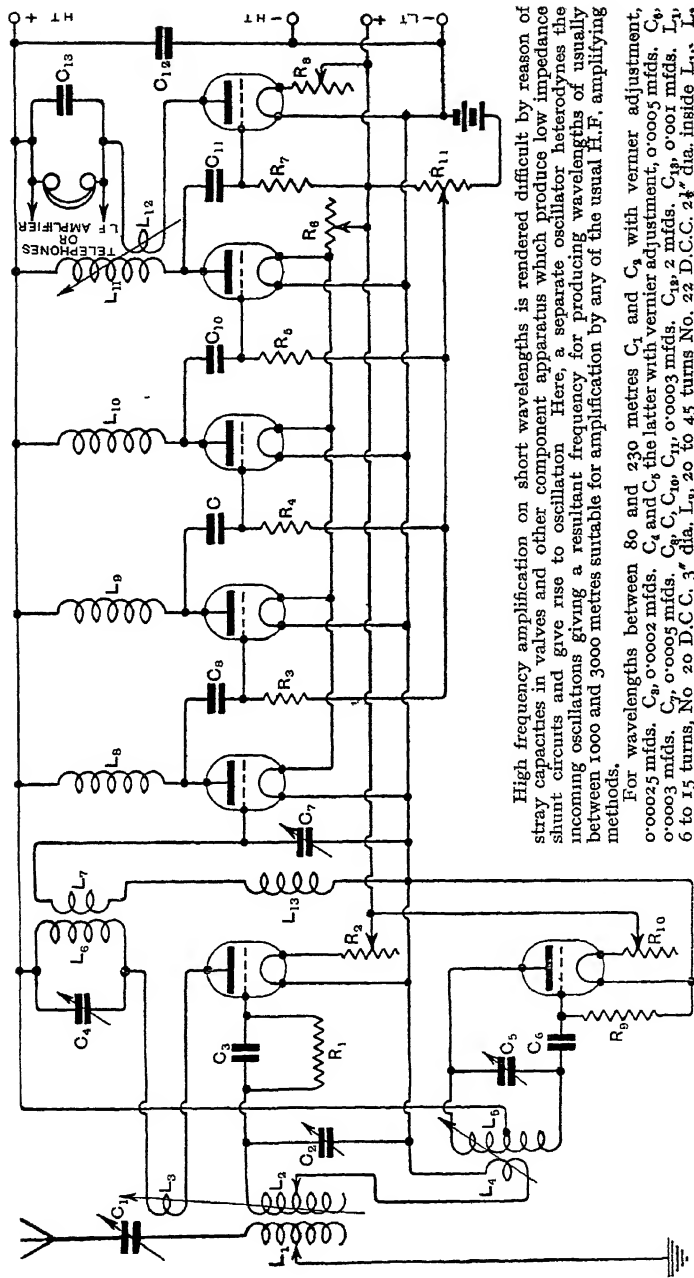
High frequency amplification on short wavelengths is rendered difficult by reason of stray capacities in valves and other component apparatus which produce low impedance shunt circuits and give rise to oscillation. Here, a separate oscillator heterodynes the incoming oscillations giving a resultant frequency for producing wavelengths of usually between 1000 and 3000 metres suitable for amplification by any of the usual H.F. amplifying methods.

For wavelengths between 80 and 230 metres C_1 and C_9 with vernier adjustment, C_4 and C_5 the latter with vernier adjustment, 0·0005 mfds. C_6, 0·00025 mfds. C_3, 0·0002 mfds. C_2, C, C_{10}, C_{11}, 0·0003 mfds. C_{12}, 2 mfds. C_{13}, 0·001 mfds. L_1, 6 to 15 turns. No. 20 D.C.C. 3″ dia. L_2, 20 to 45 turns No. 22 D.C.C. 2¼″ dia. inside L_1. L_3, 10 turns No. 26 D.C.C. on ball former inside, L_1, L_7, L_4, 5 turns No. 22 D.C.C. on ball former inside L_6 at plate end. L_6, 70 turns No. 24 D.C.C. 2¼″ dia. L_5, a honeycomb or pile wound coil having an inductance of about 70 millihenries. L_7, a loosely coupled coil of about 10 millihenries. L_8, L_9, L_{10}, L_{11}, 90 millihenries. L_{10}, 30 to 60 millihenries. L_{11}, 60 millihenries.

SINGLE VALVE SUPERSONIC HETERODYNE—
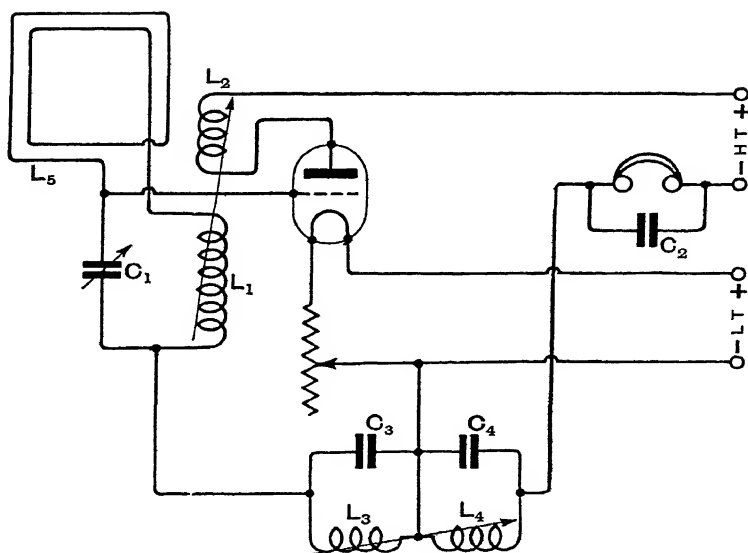## H.B. 83, H.B. 84

A single valve is here caused to operate both as heterodyne oscillator and first valve of a supersonic heterodyne receiver.

RECEIVER WITH SEPARATE HETERODYNE
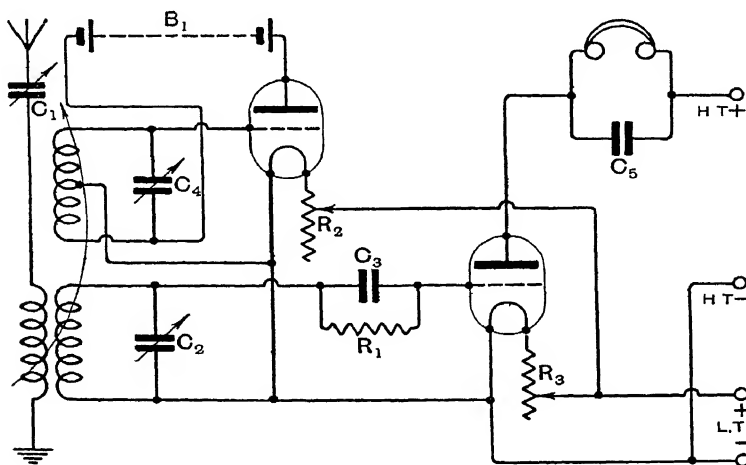
A receiver making use of a separate heterodyne to produce beat effects. Values can be gleaned from other circuits according to wavelength.

SINGLE VALVE SUPER-REGENERATIVE
## SET—H.B. 85

This is the Armstrong super-regenerative circuit shown in its best known form. It is customary to operate this set as a frame aerial because it is essential for the grid circuit coil to possess very little damping. Alternatively, the grid circuit inductance may be very loosely coupled to an inductance connected in an aerial circuit. The sizes of the closed circuit and reaction coil and the closed circuit condenser will be found on earlier circuit pages according to wavelength. The condensers in the oscillator circuit have a value of 0·002 mfds. while the coils, which are identical must be chosen to produce closed circuits having a wavelength between 15,000 and 30,000 metres. The correct operation of this circuit depends upon accurate balancing of the amplitude of the oscillations set up by the grid and reaction coils with those produced by the oscillator coils and for this reason the coupling between them must be made critically variable.

SUPER-REGENERATIVE ARRANGEMENT—
H.B. 86

WITH TWO VALVES
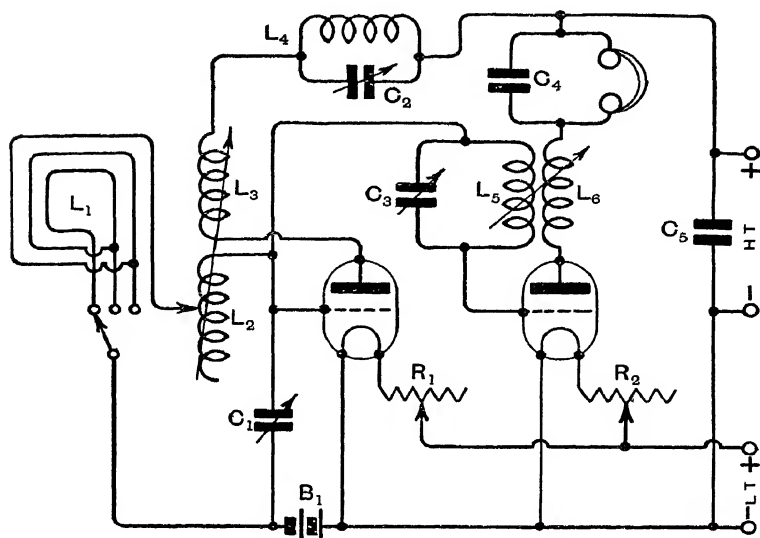
Oscillations of a high amplitude are set up by the coupling between L_2 and L_3 and these are periodically damped by potentials fed to the grid from the oscillator consisting of the inductances L_5 and L_6. The constant note produced by the second valve oscillator may be removed by a filter circuit. For efficient working it is necessary for oscillations to build up to high amplitude in L_2 very rapidly and thus the damping of this circuit by radiation must be kept as low as possible   The lowering of the oscillation frequency of the circuit C_3, L_5 improves the sensitiveness of this receiver but as the frequency reaches audibility it becomes more difficult to suppress with a filter in the telephone circuit. This is also one of the well-known arrangements of the Armstrong super-regenerative circuit and in view of the position of the telephones it would appear that the oscillations set up by the oscillator valve are modulated by its grid circuit which is linked into the frame tuning circuit. L_1, L_2, L_3, usual values to be found elsewhere in this book according to wavelength. L_4, L_5 and L_6 90 millihenries (or the usual 1250 coil) C_1, 0·00075 mfds. C_2 and C_3, 0·0015 mfds   Considerable experimental experience is necessary before setting up a receiver of this type.
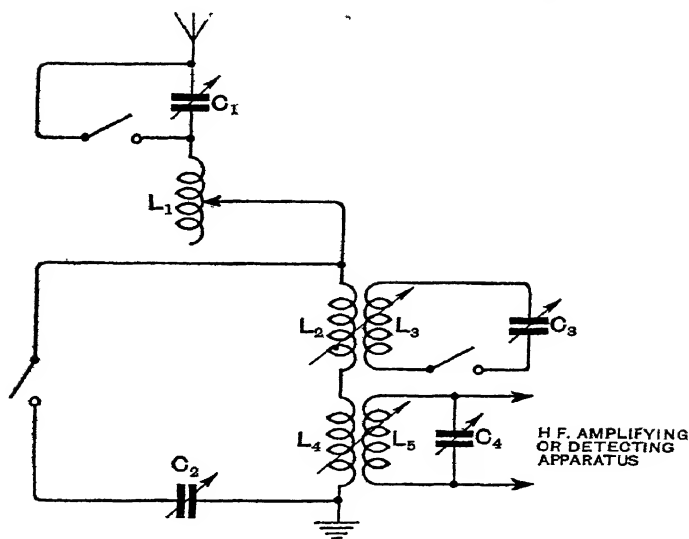
A combination of simple rejector systems has been introduced into this circuit. C_1 is the series aerial tuning condenser and C_2 the parallel tuning condenser. By suitably combining the values of C_1 and C_2 in conjunction with the inductance L_1, the circuit may be rendered very selective. The absorption circuit L_3, C_3, is variably coupled to L_2 and is very effective for removing an unwanted signal. Loose coupling between L_4 and L_5 further improves the selectivity.

For wavelengths up to 700 metres, C_1, 0·0005 mfds C_2, C_3, C_4, 0·00025 mfds. L_1, a plug-in coil or tapped inductance having a maximum equivalent value to a No. 100 plug-in coil. L_2, L_3, L_4 and L_5 also preferably plug-in coils in two-coil holders having the usual values for short wavelengths.

RECORDING CIRCUIT—H.B. 88
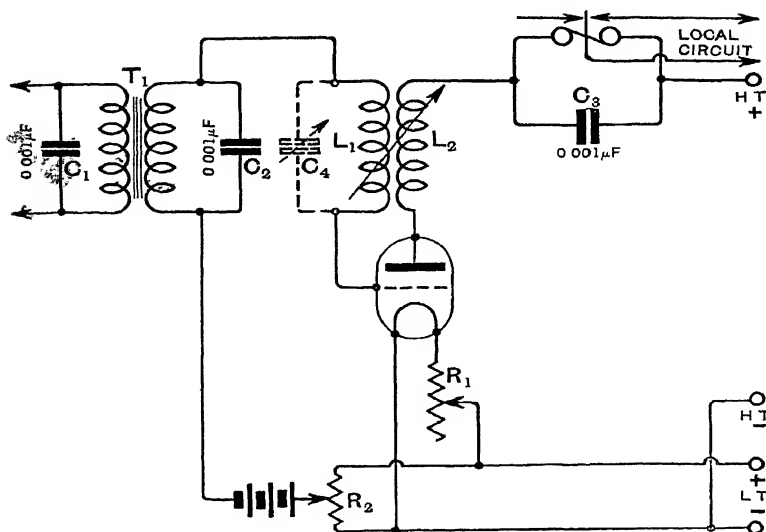
There are a number of methods of operating recording apparatus with morse signals. Provided a recording speed of not more than 30 to 40 words is required and the transmitted signals are continuous wave no great difficulty exists. One of the simplest systems consists of connecting a crystal or valve rectifier between the last stage of the low frequency amplifier and the relay. In the circuit shown above an oscillator is set up, L_1, L_2 which may, with advantage, be tuned with the condenser C_4 and the oscillation amplitude is controlled by the potential delivered from the secondary of the intervalve transformer T_1. For slow speed working this circuit gives very good results but for recording at high speeds quenching arrangements have to be introduced and many mechanical difficulties are met with in constructing apparatus that will follow the transmission.

SMALL SPARK TRANSMITTER—H.B. 89
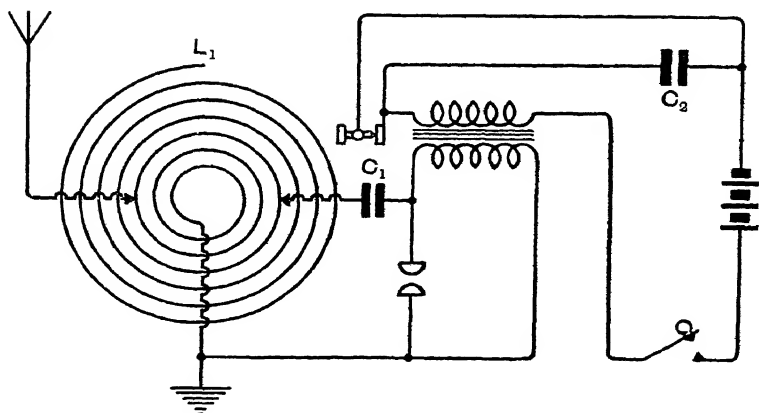
This is a very simple form of transmitter which derives its power from a spark coil. For greater output the coil and battery would be replaced by a step-up transformer connected to an alternating current supply which should preferably have a frequency greater than 250 cycles in order that a high pitched note may be obtained. The transmitting inductance L_1 is a copper strip spiral of about $\frac{1}{2}''$ or $\frac{3}{8}''$ in width by No. 24 S.W.G. A usual value for the condenser C_1, for short wavelengths is 0·003 mfds. Reduced damping in the closed circuit may be obtained by improved quenching at the gap and in particular the type which consists of a number of specially shaped discs and spaced with rings of mica, is recommended. When alternating current is supplied from a generator it is customary to fit a rotary synchronous spark gap on its shaft but the merits of this form of quenching are doubtful. A hot wire ammeter should be connected in the aerial or earth leads or alternatively, a low candle power 4-volt metal filament lamp may be used with sets operating from small spark coils

LOW POWER VALVE RECTIFIER—**H.B. 90**
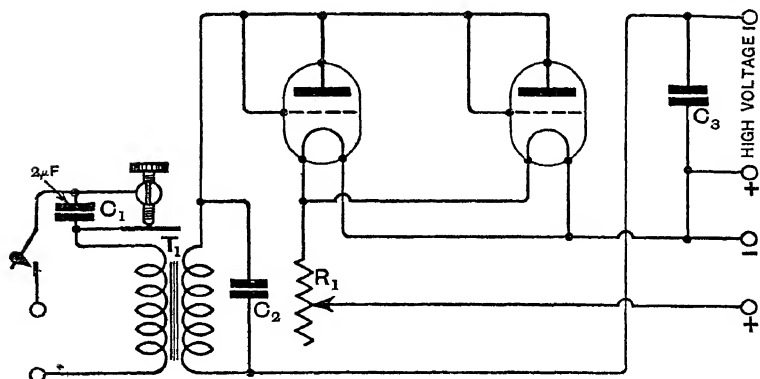
The circuit is shown here of a low power valve rectifier for providing high tension current for a small C W or telephony transmitter. Receiving valves may be used and their filaments need to be heated from an accumulator well insulated from earth. The battery leads to the coil should be reversed to determine the arrangement that produces the best output. C_2 is not essential and may have a value of about 0·001 mfds , while C_3 must be as large as is conveniently possible, say 0·5 mfds., and should be constructed to withstand high potentials. The vibrator interrupter must be run at high speed.

NEON LAMP RECTIFIER—**H.B. 91**
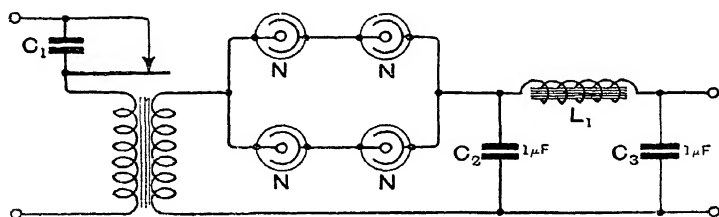
It would probably be more correct to describe this circuit as a smoother than as a rectifier. The conductivity of the neon lamps breaks down with a certain initial voltage and thus it is necessary to make several tests to determine the number of lamps which must be arranged in series to pass current when the voltage approaches a peak value. Paralleling the lamp permits of the passage of more current and one of the objections to this system of smoothing is the somewhat limited current output Tests must be made by reversing the leads to the input of the coil.

FULL WAVE VALVE RECTIFIER—H.B. 92
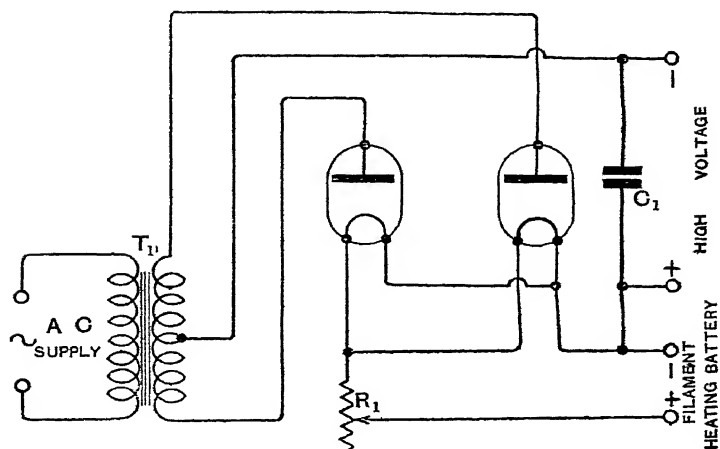
Where A C. supply is available this is one of the best methods of obtaining H.T. supply by stepping up and rectifying. The capacity of the condenser C_1 will need to be large if the frequency of the supply is low

RECTIFIER WITH A.C. FILAMENT HEATING— H.B. 93
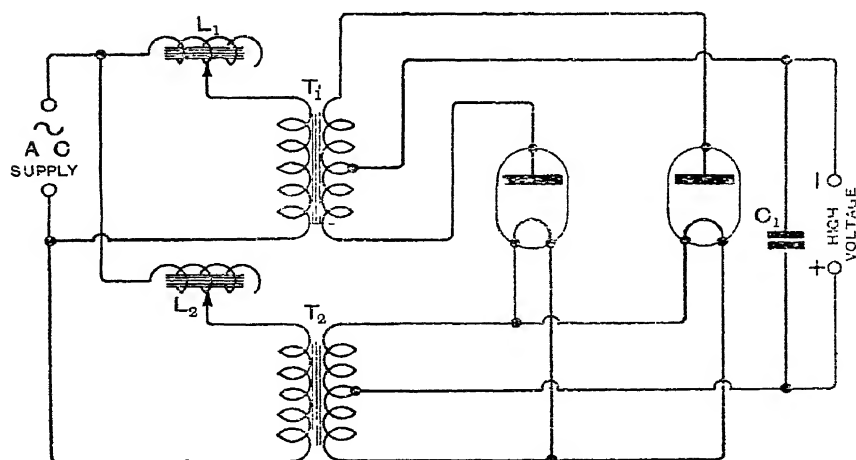
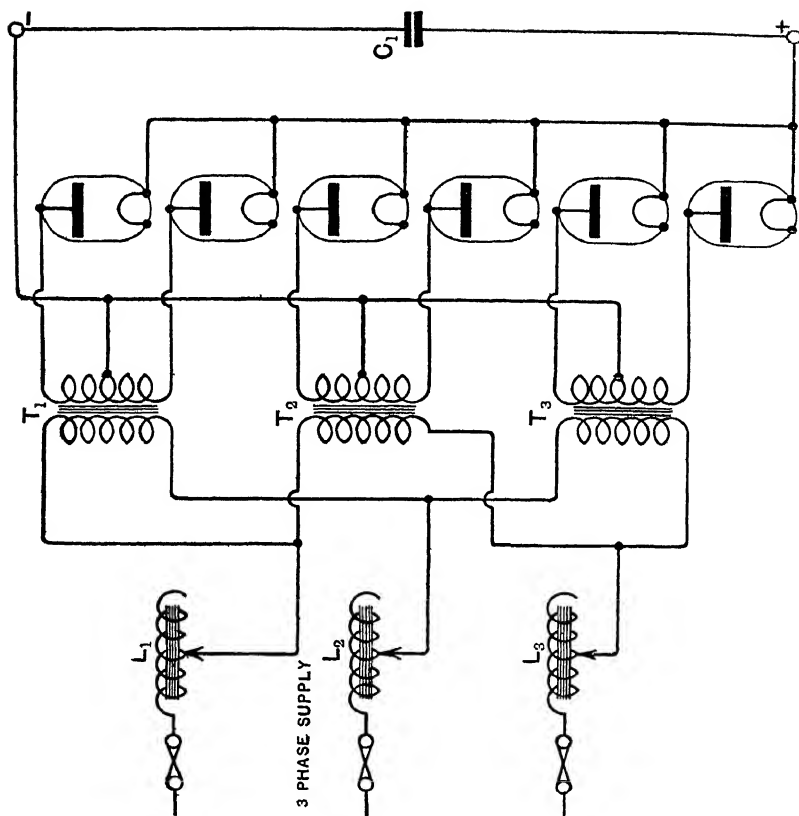It is preferable to heat the rectifier valve filaments with alternating current and this can easily be arranged by a step-down transformer built as part of the power transformer or as a separate unit. The adjustable low frequency chokes L_1 and L_2 are very convenient for power regulation particularly if the frequency is above 200, when their adjustment becomes critical.

3 PHASE SUPPLY

This circuit shows the method of utilising a three phase supply for obtaining high potential D C and the merit of the arrangement is the ease with which the ripple is suppressed. Three phase currents may be obtained from a rotary convertor fitted with three slip rings which are connected to points on the armature winding 120° apart, though with a two-pole machine the frequency may be on the low side.

The reader is reminded that synchronous mechanical rectifiers can be used in the case of machines delivering frequencies of over 200 cycles. With ordinary single phase it is only necessary to step-up through a transformer, the ends of the secondary of which are taken *via* a pair of brushes to slip rings with branching segments. A third brush synchronously adjustable makes circuit with each end of the transformer winding alternatively and delivers uni-directional current in conjunction with a mid-point tap in the secondary winding.

96

OSCILLATING SYSTEM FOR TRANSMITTER—
H.B. 95

GRID COIL OSCILLATOR

COUNTERPOISE
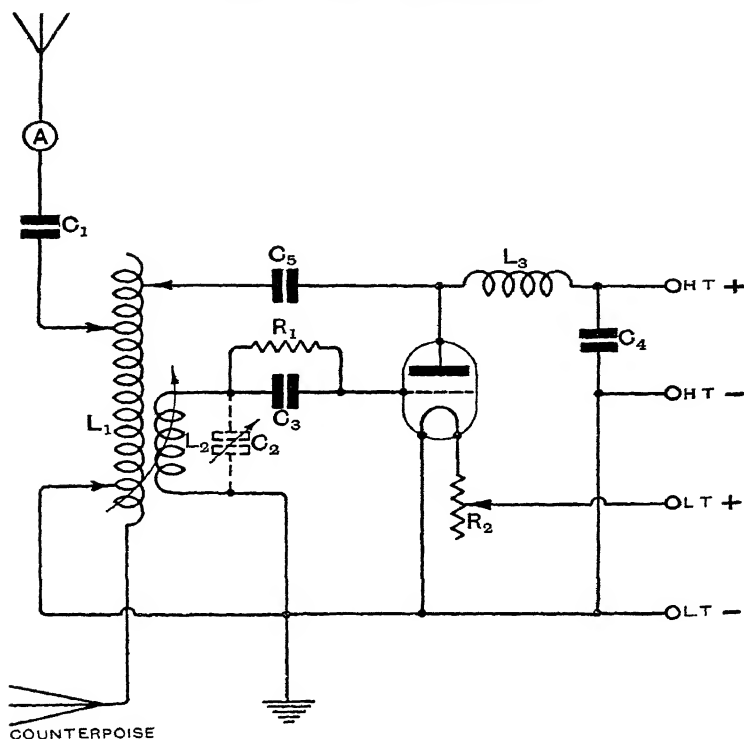
The diagram shows one of the most generally used forms of oscillating circuit employed for transmission. For low power working on a wavelength of 440 metres with an amateur aerial of average dimensions the inductance L_1 should consist approximately of about 45 turns 7″ in diameter. It may be built with ¼″ or ⅜″ by No. 24 S.W.G. copper strip or No 12 round copper wire may be used. The number of turns given is only an approximate guide, for of course the inductance will depend materially upon the spacing of the turns. Using this coil, suitable tappings can be made for working on wavelengths between 100 and 200 metres, though if short wavelengths only are required 18 turns will suffice provided it is possible to introduce additional turns in the anode tap circuit between the condenser C_5 and the inductance. The grid coil L_2 may consist of about 30 turns of No. 20 double cotton covered wire, 3½″ in diameter for 440 metres, and 18 turns for 200 metres and below. A difficulty often experienced in using this circuit on short wavelengths is that considerable wavelength change is produced as alterations are made in the grid coil coupling. The condenser C_1 should preferably have air dielectric and for short wavelengths a value of about 0·0005 mfds. Its introduction will facilitate the setting up of oscillation and the proportional increase in resistance of the aerial circuit compared with its total resistance is insignificant. Further details concerning this circuit will be found in the preliminary pages.

G

OSCILLATING SYSTEM FOR TRANSMITTER— H.B. 96

COLPITTS' ARRANGEMENT
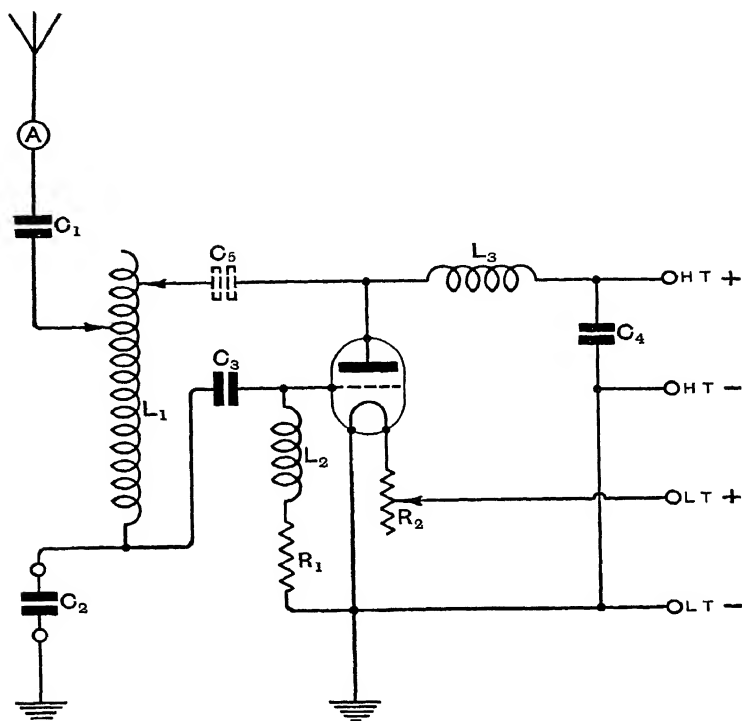
This is another form of oscillator which is sometimes recommended for operating the aerial circuit near its fundamental The condenser C_2 forms part of the tuning system of the aerial circuit and at the same time serves as the high tension feed condenser in the oscillatory circuit. The inductance L_1 is thus set at high potential above earth and the disadvantage arises that no part of the tuning circuit can be handled while the transmitter is in operation. This difficulty may be overcome by introducing the condenser C_5 Owing to the fact that L_1 may be at high potential it becomes necessary to insert the condenser C_1 in the aerial lead to avoid throwing the high voltage on to the aerial. L_2 is similar in construction to L_3 and is essential in this circuit.

TELEPHONY TRANSMITTER—H.B. 97

HARTLEY OSCILLATOR WITH CHOKE CONTROL MODULATOR
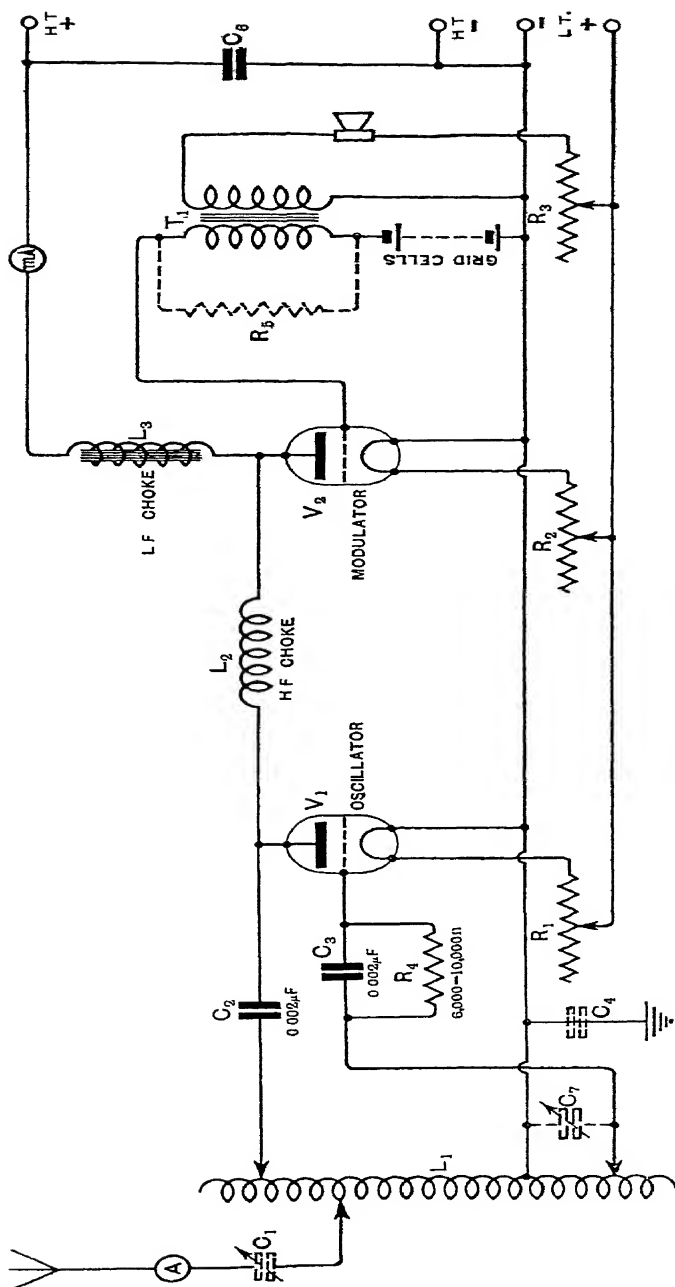
The oscillating system in this circuit is the well known Hartley arrangement which is almost universally adopted. A modulator circuit is shown connected on the choke system. The circuit is a straightforward one and constructional data will be found in the preliminary pages.

TELEPHONY SET WITH LOOSE COUPLED AERIAL—H.B. 98*

HARTLEY OSCILLATOR WITH CHOKE CONTROL MODULATOR
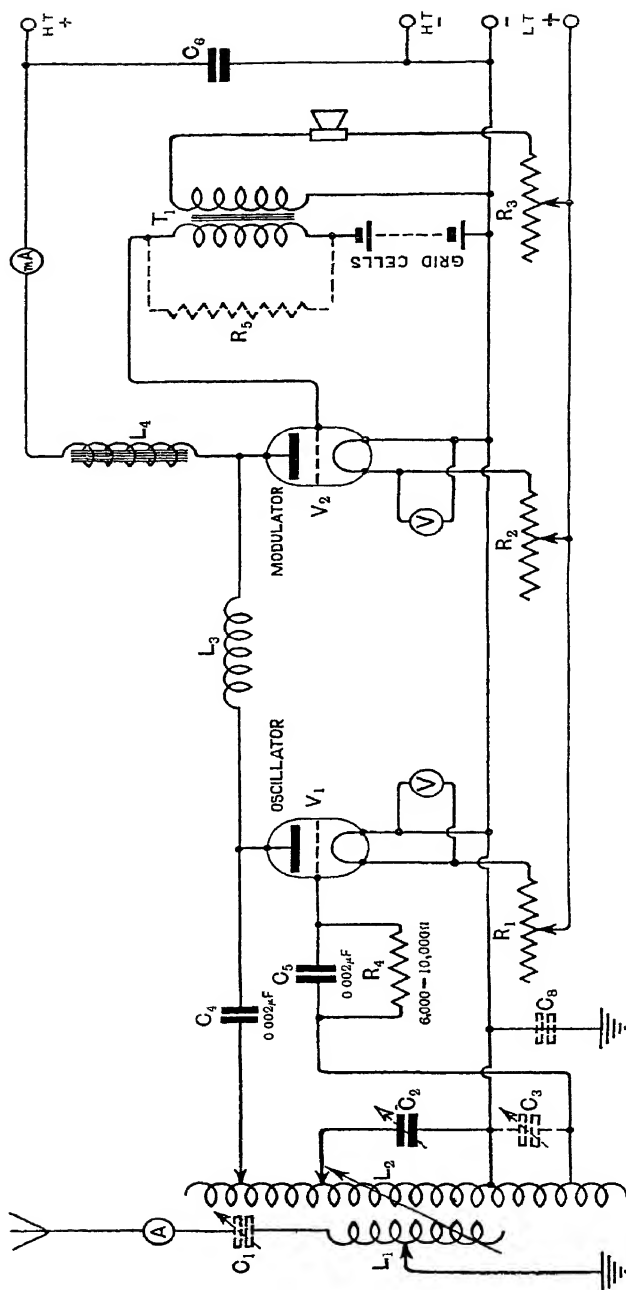
A very similar circuit to the previous one and only differing inasmuch as a loose coupled aerial circuit is introduced. L_1 may be a strip or wire wound cylindrical or spiral coil arranged to move away from L_2 or hinged to move to a position of minimum coupling. C_2 should be an air dielectric condenser and built as described in the introductory pages. It is useful to connect a hot wire ammeter in one of the leads between L_2 and C_2. This circuit is probably the best suited arrangement to the conditions met with in amateur transmission.

The connections of the master oscillator system are shown. The circuit C_4, L_6 tunes to the required wavelength and is caused to oscillate by the plate circuit coupling L_4. The variable coupling L_2, L_3 controls the grid circuit of the oscillator valve. The breakjack with its condenser C_6 allows telephones to be conveniently inserted in the plate circuit of the master oscillator, which is necessary when making preliminary adjustments. The connections of a side tone circuit are also shown which allows the operator to hear the transmitted signals while wearing the telephones which are connected to the receiver. The strength of these signals may be altered by changing the value of the inductance L_8 and a convenient method is to slide its iron core out of the winding. Loose coupling in the aerial circuit and devices shown in other circuits can, of course, be easily introduced.

SELF RECTIFYING TELEGRAPHY TRANSMITTER—**H.B. 100**
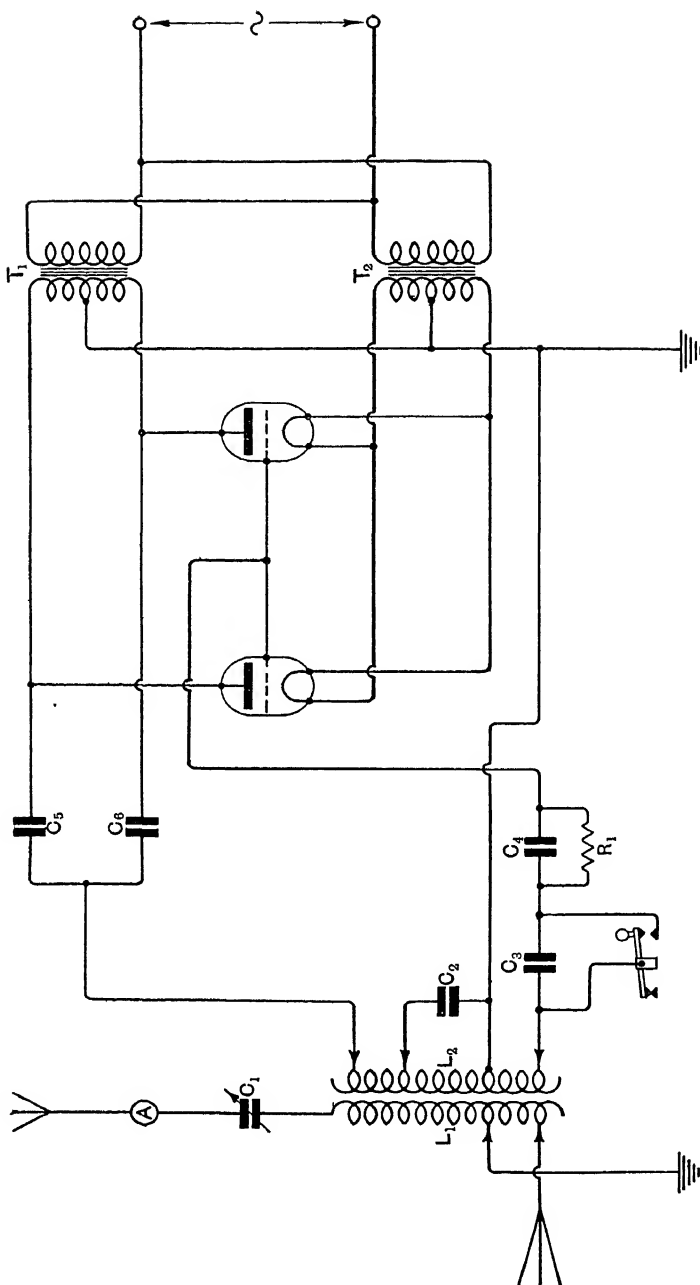
For telegraphy transmission this circuit is probably the best arrangement when the power supply is obtained from an alternating current source The condensers C_5 and C_6 have values of about 0·003 mfds C_1 and C_2 are air dielectric condensers and have been referred to in previous circuits C_3 may have a value between $\frac{1}{10}$ and 1 mfd, and the keying arrangement, though specially suitable for use in circuits where the transmitting valves are in parallel may be easily applied in other transmitting circuits shown.
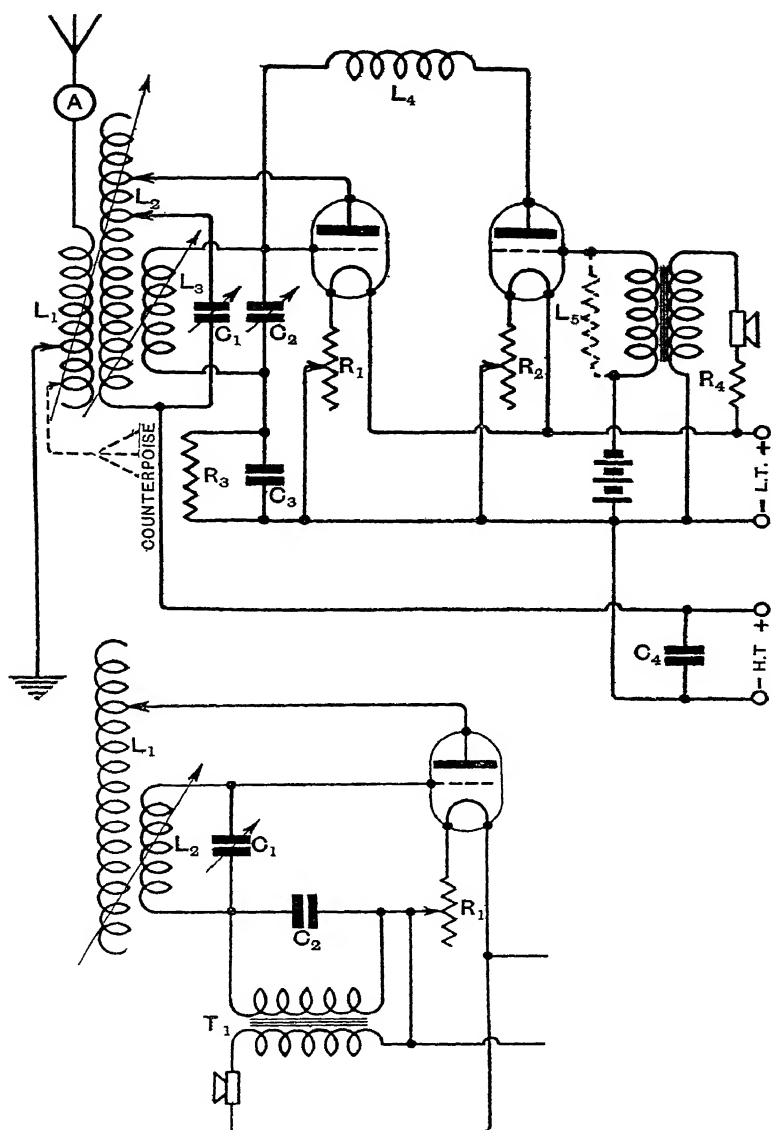
Two well known methods of grid modulation are shown here coupled up to typical oscillator circuits. Although this system of modulation is not generally recommended it gives satisfactory results on low power and makes use of either a small receiving valve for modulation, or dispenses with the additional valve as shown in the lower diagram.

BUZZER WAVEMETER—H.B. 103*
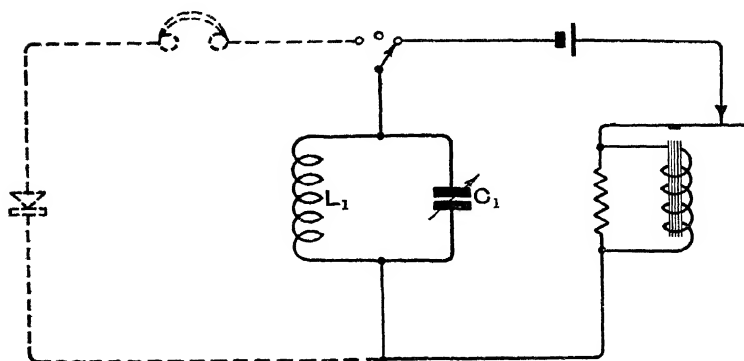
A simple buzzer wavemeter is an extremely useful instrument for tuning the receiving apparatus to any desired wavelength. The inductance L_1 may be a single layer winding of No. 26 D.C.C. on a $2\frac{1}{2}''$ former comprising 65 turns. The variable condenser C_1 having a value of 0·001 mfds., will then tune from approximately 280 to 400 metres whilst if C_1 has a maximum value of 0·0015 mfds., the range will be extended to about 550 metres. For wavelength determinations on a spark transmitter, or where an additional buzzer wavemeter is used to excite a tuned circuit for calibration tests, a switch is fitted with crystal and telephones so that reception can be carried out on the calibrated circuit of the wavemeter. This scheme of connections should not be used on wavelengths below 150 metres as the apparatus connected across the tuned circuit L_1, C_1 may appreciably alter its calibration.

2 4½ VOLT
DRY BATTERIES IN
BOTTOM OF BOX
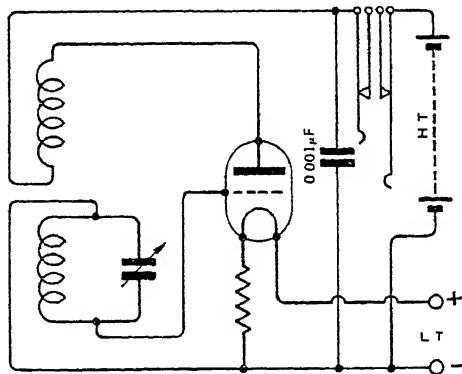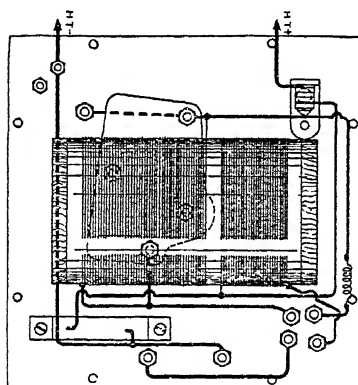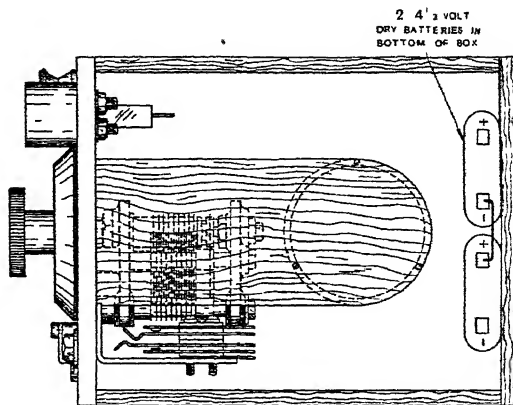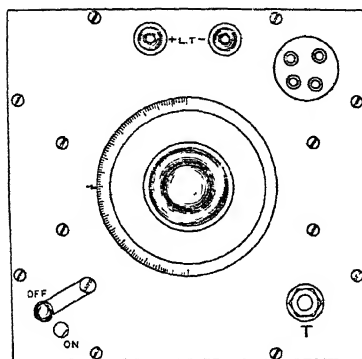
The circuit principle of an oscillator arranged for use as a wavemeter is here shown together with a typical constructional layout of a finished instrument   An instrument of this sort having fixed value inductances has only a limited range though if the grid winding is $2\frac{3}{4}''$ in diameter and consists of 60 turns of No 26 D C C the wavelength range will be about 280 to 480 metres when tuned with a 0 001 mfds variable condenser The plate coil may consist of about 30 turns of No 28 D C C.   The high tension battery consisting of a suitable number of cells is carried in the bottom of the case   The use of a breakjack instead of telephone terminals for connecting telephones in circuit is recommended   The tuning condenser used must be very carefully selected in order that its capacity may be relied upon to remain constant. A "square-law" condenser is very suitable as it facilitates calibration inasmuch as fewer readings need be taken, while the wavelength scale is evenly set out round the dial of the condenser and a uniform degree of accuracy is obtained in all settings

HETERODYNE WAVEMETER—H.B. 106

For Tuning over a Wide Wavelength Range
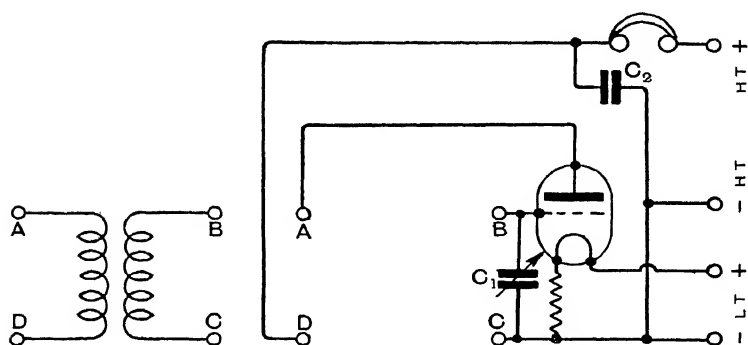
When a heterodyne wavemeter is required to cover an extensive wavelength range it becomes necessary to interchange the inductances in the plate and tuned grid circuits The two inductances may take the form of basket coils, or single layer or pile wound coils, one inside the other or end on end. The degree of coupling between the coils, as well as controlling the amplitude of the oscillations set up, materially affects their inductance. This property is made use of when setting them up to cover definite wavelength ranges while the coils must be securely fixed in their relative position so that the calibration may remain reliable The condenser C_1 may have a value of 0·0015 mfds or 0·002 mfds , but as this renders accurate reading on short wavelengths difficult an improvement is to employ two reliable 0 001 mfds , condensers operated simultaneously by means of a common spindle These condensers are used in series with one another on the shorter wavelengths and in parallel on long wavelengths. The series arrangement is obtained by connections from the fixed plates only, leaving the moving ones disconnected. When the two sets of fixed plates are joined together and connection picked up from the moving plates the parallel arrangement is obtained

VALVE CHARACTERISTIC DETERMINATION—
H.B. 107
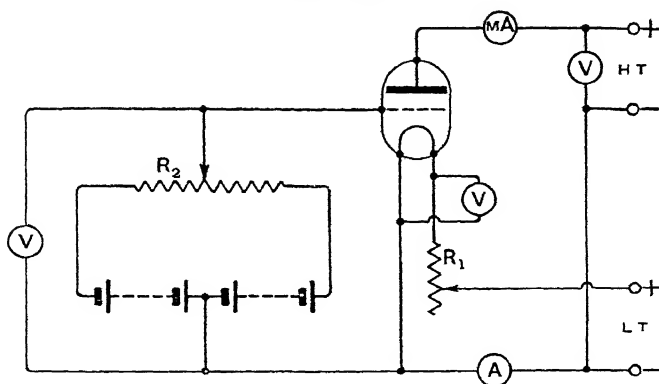
This circuit is arranged for making determinations in the relationship between filament current, grid potential, plate potential and plate current and thus determines the properties of a valve.

CONDENSER CALIBRATING CIRCUIT—H.B. 108
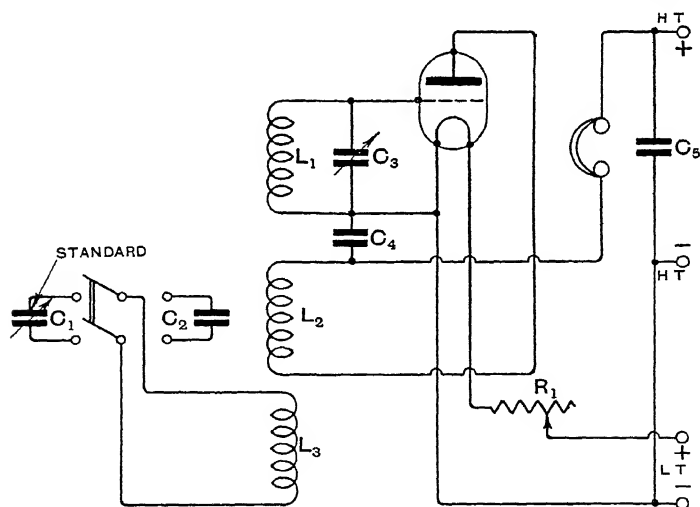
A double click in the telephones indicates oscillation in the circuit L_1, C_3, L_2 When C_1, L_3, comes into resonance with L_1, C_3 there is a change in the value of the current through the telephones. It is only necessary to obtain this adjustment with C_2 in circuit and then change over to C_1 and adjust the standard variable condenser to a setting where the effect is again observed. L_1, L_2, L_3 are best arranged as plug-in coils in a three-coil holder so that the coupling can be critically varied   The telephones may be substituted by a milliammeter while the condenser C_2 may be connected in parallel across the condenser C_1 after the circuit has been adjusted to resonance and thus the value of C_3 will be represented by the reduction it is necessary to make in the value of C_1 to restore resonance.

DIRECT CURRENT MAINS—**H.B. 109** AND **H.B. 110**

FOR VARIABLE VOLTAGE AND ACCUMULATOR CARRYING
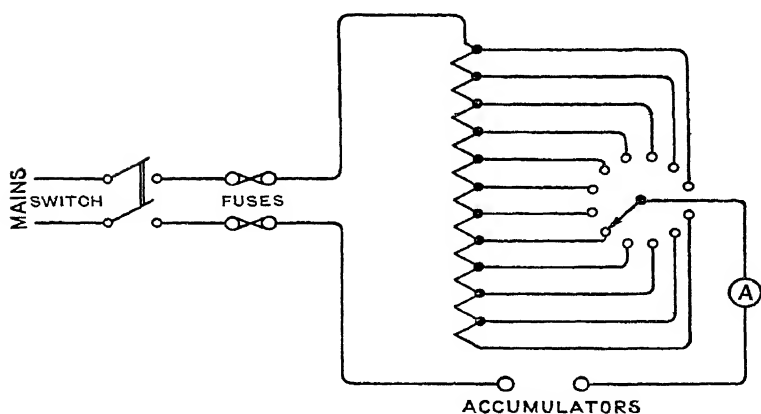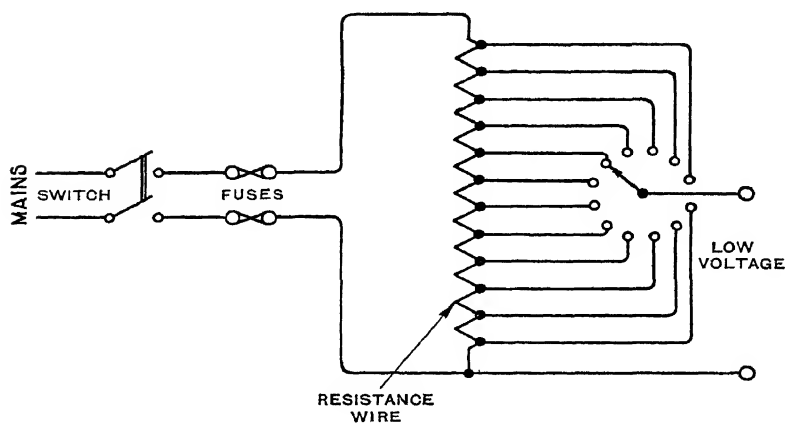
Methods are shown for controlling first the potential delivered from high voltage D C supply mains, and in the lower figure for controlling the current such as is necessary for accumulator charging   The resistance wire, which may have to pass several amperes, can be wound as a number of spirals about 18″ in length and attached to small china bobbin insulators carried on stiff asbestos board

H.B. 111, H.B. 112, AND H.B. 113

Where D C mains are available, HT current is probably best derived from accumulators charged from the mains. The left hand diagram shows how to charge the HT. accumulator through a lamp. It is important for the lamp to be connected in the lead which is at high potential above earth The centre figure shows how, by means of a switch, the supply circuit can be easily broken for accumulator charging through the house lighting circuit. On the right is an accumulator charging board in which the current through the battery is regulated by means of lamps. The accumulators must be connected on the earth side of the mains and every care must be taken to prevent acid which may overflow from making contact with earth. Batteries on charge must be well insulated from earth, and should not be left for long intervals unattended.

VIBRATOR RECTIFIER—**H.B. 114**

For Accumulator Charging from A.C. Supply

BATTERY
ON CHARGE
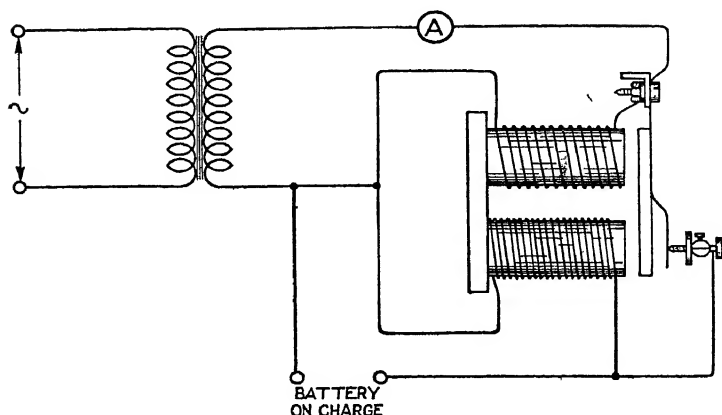
One of the simplest forms of rectifier for accumulator charging from A.C. mains consists of a buzzer interrupter. A portion of the alternating output is fed on to a winding (upper coil) on the buzzer magnet which acts with, or in opposition to, the constant field set up by the discharge of a fraction of the battery current round the lower coil. Actually, half of both the windings is arranged on each of the poles The magnetic fields due to the alternating and polarising currents cause the armature to be attracted once every complete cycle, thus breaking the current supply from the battery whenever it is flowing in the incorrect direction. When the apparatus is correctly set up, which is easily accomplished by testing the effect of reversing one of the coils, it does not matter which way round a battery is connected to the charging terminals, for a reversal of its poles results in a reversal of the polarising current. For sparkless running it is very necessary for the natural period of oscillation of the armature to be equal to the frequency of the supply and this is usually achieved by adjusting its length.

FULL WAVE ELECTROLYTIC RECTIFIERS—
H.B. 115 AND H.B. 116

FOR H.T. SUPPLY OR H.T. BATTERY CHARGING
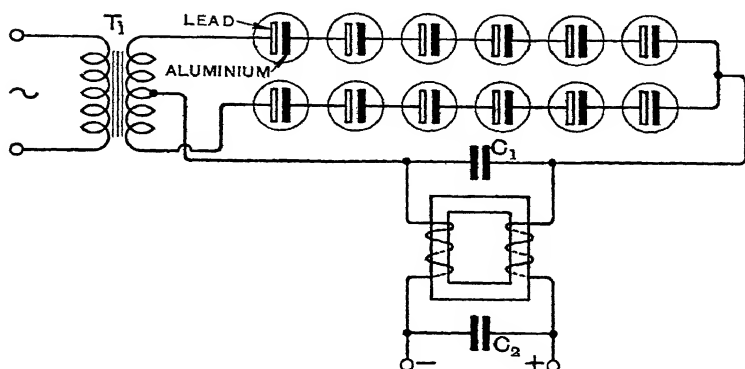
Rectifiers of the electrolytic type are frequently used for H.T. supply for receiving and transmitting apparatus and for accumulator charging. The plates are of pure aluminium and lead immersed in a saturated solution of ammonium or sodium borate (borax) or ammonium or sodium phosphate. The solution is covered with a floating layer of paraffin. In this rectifier, which has only a small current output, the plate area immersed need not exceed 2″ by ½″. The plates will require "forming" If connected directly to a transmitter for plate current supply suitable smoothing or filter circuits will be needed.

FOR L.T. ACCUMULATOR CHARGING
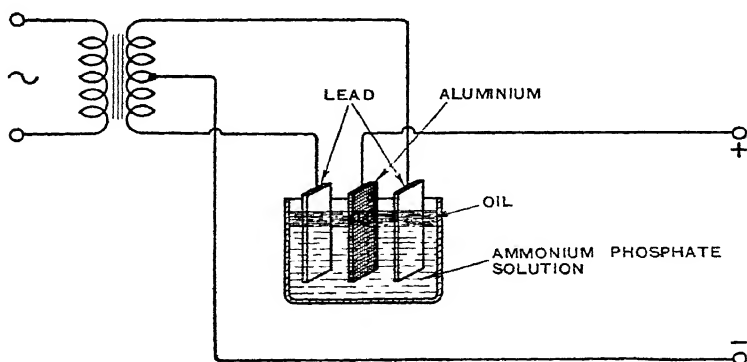
Considerably larger cells are used with this rectifier and one of the difficulties experienced in its operation is that of suitable cooling of the solution.

III

LOUD SPEAKER DISTRIBUTION—H.B. 117

Remote Control of Receiving Apparatus
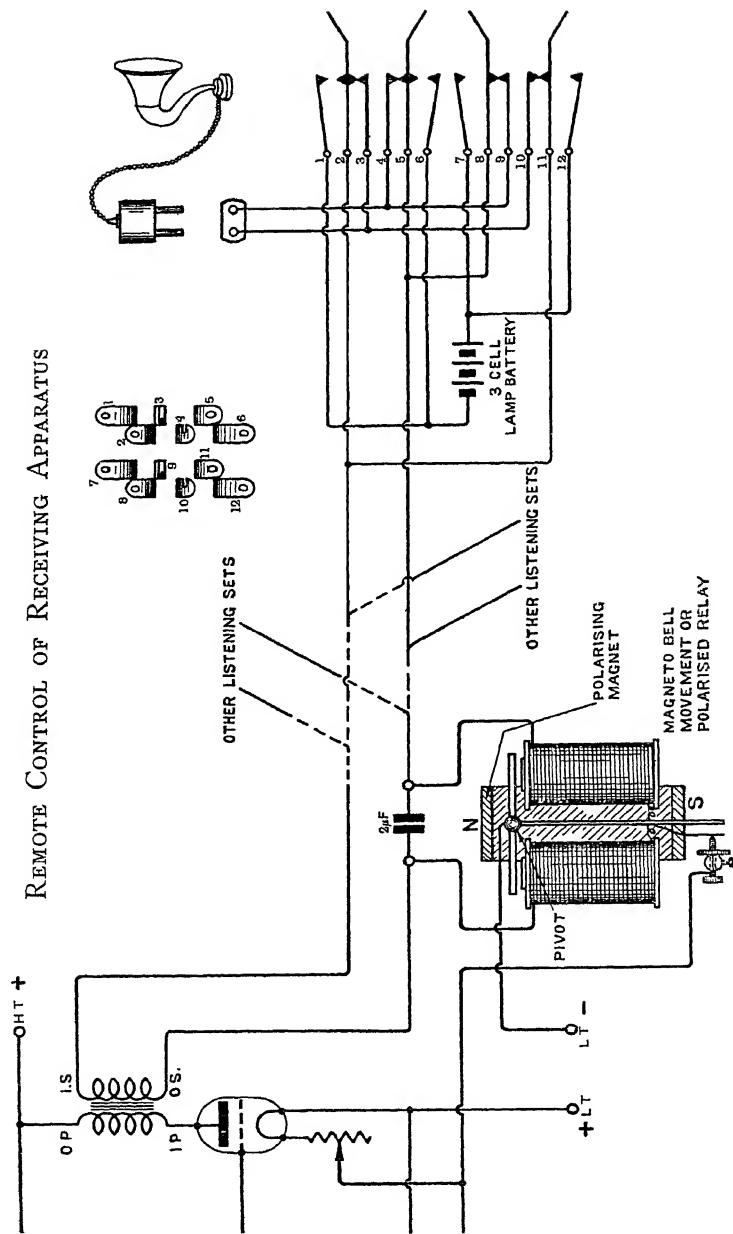
A feature of this system is that no continuous current is passing down the lines while they are carrying the fluctuating currents for loud speaker operation. A flash lamp battery is enclosed in a small case which also carries a 12-point Dewar key at each listening point. The relay may be constructed from a polarised telephone bell or a standard polarised relay employed with its tension spring suitably adjusted so that the armature will remain in either position. Moving the signalling key up or down switches the valve filament circuits on or off whilst the key is left in its centre setting for listening or normal

FOUR-ELECTRODE VALVE CIRCUITS
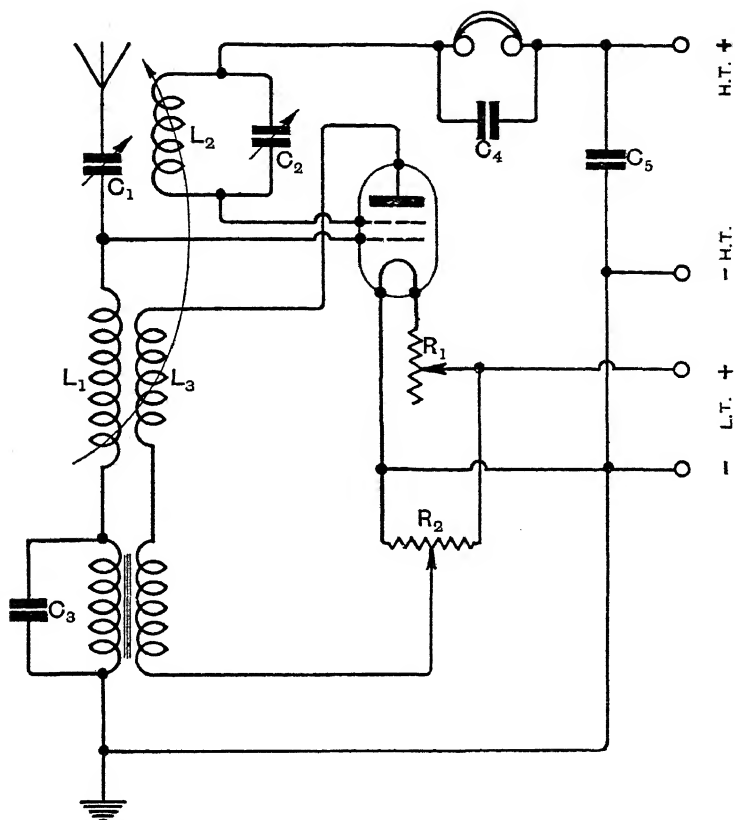
The principal application of the four-electrode valve is to obtain simultaneous high and low frequency amplification. In this circuit the potential developed across the inductance L_1 influences the grid which is nearest to the filament. High frequency amplification is obtained in the tuned closed circuit L_2, C_2, whilst low frequency amplification is produced through the feed back transformer, which is connected to the aerial circuit.

Reaction is obtained by the inductance L_3, and also by linking up L_2 with the aerial circuit.

SYMBOLS USED IN WIRELESS CIRCUITS

Single pole, single throw switch, such as is useful for breaking valve filament circuits, etc.
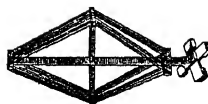
Double pole, double throw switch useful for series parallel condenser connections and for switching valve amplifiers in and out of circuit.

The symbol represents a single cell which may be a dry battery as shown or one cell of an accumulator The longer stroke represents the positive terminal

A battery of cells such as a 6-volt accumulator, comprising 3 sections or a H T battery

The aerial

Frame aerial.

Earth connection.

Single layer tuning inductance wound with insulated wire on a cardboard or ebonite former.

An inductance which is made variable by a number of tappings.

Inductance of the plug-in type.

The neon lamp sometimes used for power rectification and also for use in wavemeter circuits.

Intervalve transformer.

Intervalve transformer with primary and secondary connected in series to form a L.F. choke.

Fixed valve condenser.
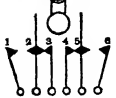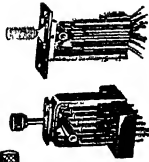
Variable condenser for tuning purposes.

Crystal detector.
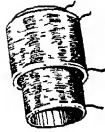
Two inductances coupled together, such as might be used for a loose coupled aerial circuit or a H.F. intervalve transformer

Two plug-in inductances with variable coupling

Variometer
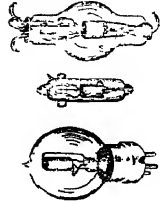
Valves with three electrodes for reception and transmission
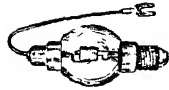
A two-electrode valve such as is used for rectification in the H T supply circuit of a transmitter.

Variable resistance such as is used in a filament circuit.

Telephone jack with contacts for switching L.F. circuits.

Keys for use in high and low frequency circuits.

Fuse.

Milliammeter.

Electrolytic rectifying cell.

Telephone receivers.

Direct current dynamo.

Alternating current generator.

Voltmeter.

Ammeter.

Resistance of fixed value.

Potentiometer
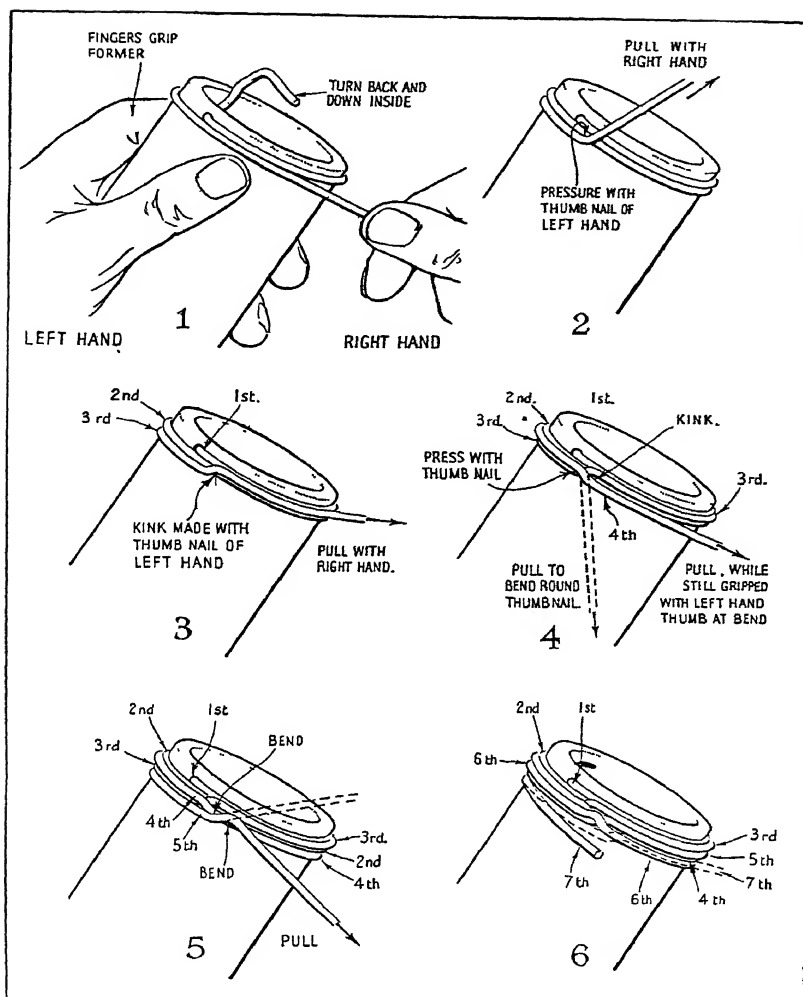
PILE WINDING

The figures show step by step the method of pile winding. Care must be taken to keep the wire quite tight so that there is no chance of the underneath turns slipping apart and thus permitting the outside turns to slip down.

No 26 S W G, with a double covering of either silk or cotton, pile winds very well, whilst finer wires may be used if reasonable care is taken.

Three and four pile winding is accomplished by building up the requisite number of layers in pyramid form and then banking the additional turns in layers on to one side of the pyramid

TUNING RANGE IN METRES OF COMMERCIAL TYPES OF INDUCTANCES

Compiled from data furnished by manufacturers   Minimum wavelength values are only approximate and will depend upon the capacity of the tuning condenser when at zero setting.

Make	Coil No	Inductance Microhenries	Distributed Capacity Microfarads	P M G Aerial Series		0.00075 Mfds Condenser Parallel		Closed Circuit with various Tuning Condensers							
								0.00025 Mfds		0.0005 Mfds		0.00075 Mfds		0.001 Mfds	
				Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Atlas	25	..	..	..	..	..	..	cap 0.0003 57	230	..	300	..	..	..	375
	35	..	..	..	..	..	..	83	300	..	380	..	..	..	515
	40	..	..	..	..	..	..	95	360	..	470	..	..	..	650
	50	..	..	..	..	..	..	124	425	..	570	..	..	..	780
	65	..	..	..	..	..	..	140	475	..	680	..	..	..	1,000
	75	..	..	..	..	..	..	170	620	..	800	..	..	..	1,120
	100	..	..	..	..	..	..	230	850	..	980	..	..	..	1,520
	150	..	..	..	..	..	..	340	1,000	..	1,520	..	..	..	2,300
	200	..	..	..	..	..	..	420	1,400	..	2,300	..	..	..	3,100
	250	..	..	..	..	..	..	500	2,000	..	2,900	..	..	..	4,150
	300	..	..	..	..	..	..	680	2,500	..	3,400	..	..	..	4,940
	400	..	..	..	..	..	..	800	3,400	..	4,400	..	..	..	6,380
	500	..	..	..	..	..	..	1,020	4,250	..	6,000	..	..	..	8,900
	600	..	..	..	..	..	..	1,200	4,750	..	7,000	..	..	..	12,100
	750	..	..	..	..	..	..	1,500	6,000	..	8,000	..	..	..	15,000
	1,000	..	..	..	..	..	..	2,000	8,100	..	9,800	..	..	..	20,000
	1,250	..	..	..	..	..	..	2,200	9,750	..	15,000	..	..	..	22,000
	1,500	..	..	..	..	..	..	2,900	12,500	..	18,000	..	..	..	26,000
Burndept	A	1.6	7	80	150	..	..	0.0002 mfds ..	..	..	..	..	..	..	..
	B	13	8	110	190	..	..	..	110	..	170	..	210	..	240
	C	25	10	140	230	250	330	..	150	..	230	..	285	..	325
	S 1	37	10	150	260	300	380	..	175	..	280	..	330	..	375
	S 2	58	10	165	290	340	470	..	220	..	355	..	420	..	475
	S 2½	84	9	180	340	390	560	..	265	..	425	..	505	..	575

Table of wavelength / capacity data for receiving sets. Column headings (applying to the marked columns): **Capacity of condenser 0·00065** (col 6), **Natural Wavelength** (col 7), **0·0001 mfds.** (col 8). Blank cells correspond to "··" in the original.

Burndept—contd.

Model	1	2	3	4	5	6 (0·00065)	7 (Nat. Wave)	8 (0·0001)	9	10	11	12	13
S.3	110	9·5	200	360	420	640	305		490		580		655
S 4	220	9·5	260	470	590	900	430		690		820		930
75	294	32·5	350	570	700	1,100	520		820		970		1,095
100	583	27	450	750	950	1,450	730		1,150		1,350		1,530
150	1,193	22	650	1,050	1,300	2,100	1,035		1,625		1,930		2,180
200	2,300	21	900	1,450	1,900	3,000	1,420		2,260		2,670		3,020
300	4,770	17	1,250	2,000	2,600	4,100	2,050		3,250		3,850		4,350
400	9,600	17	1,750	2,900	3,700	5,800	2,900		4,600		5,450		6,200
500	23,550	20·5	2,600	4,300	5,500	9,000	4,550		7,250		8,600		9,750
750	53,250	19	4,000	6,600	8,500	13,500	6,900		11,000		13,000		14,600
1,000	104,650	17			12,500	21,000	9,650		15,300		18,200		20,500
1,500	182,000	22			16,500	28,000	12,800		20,200		23,800		27,000

Gambrell

Model	1	2	3	4	5	6 (0·00065)	7 (Nat. Wave)	8 (0·0001)	9	10	11	12	13	14
a/2		4	70	105	130	210	42	110						
a	32	4	110	165	200	315	65	175	68	242	72	288	75	330
A	79	4	175	260	325	510	105	275	110	385	115	460	120	525
B	197	5	275	415	495	825	170	440	180	595	190	740	200	855
C	364	6	380	530	690	1,150	240	610	260	875	275	1,040	285	1,200
D	745	6	530	750	975	1,625	340	880	360	1,225	380	1,460	400	1,700
E	2,240	8	880	1,200	1,600	2,700	575	1,500	615	2,100	655	2,520	690	2,875
F	5,280	9			2,550	4,200	890	2,300	945	3,170	995	3,800	1,040	4,350
G	12,400	11			3,650	6,200	1,350	3,500	1,465	4,900	1,520	6,000	1,575	6,800
H	26,300	14			5,800	10,000	2,000	5,200	2,090	7,100	2,175	8,400	2,250	9,500
I	62,260	17			8,900	14,500	3,150	8,000	3,260	11,100	3,350	13,000	3,425	14,500
J	177,300	21			14,000	24,000	5,500	13,300	5,620	19,100	5,750	21,500	5,900	25,000

Igranic

Model	1	2	7 (Nat. Wave)	8 (0·0001)	10	13	14
C 1						110	285
C 2						205	500
C 3						348	706
C.4						495	1,050
25	30·2	26	53	116	237		330
35	60·3	34	85	170	338		471
50	134	47	148	265	510		706
75	297	38	200	381	752		1,046
100	517	43	281	512	1,000		1,383
150	1,151	31	355	732	1,473		2,053
200	2,150	28	462	987	2,010		2,800
250	3,480	22	522	1,230	2,540		3,560
300	4,980	27	692	1,495	3,040		4,268

TUNING RANGE IN METRES OF COMMERCIAL TYPES OF INDUCTANCES—continued

Make	Coil No.	Inductance Micro-henries	Distributed Capacity, Micro-microfarads	P.M.G. Aerial. 0·00075 Mfds.' Condenser. Series Min	Series Max	Parallel Min	Parallel Max	Closed Circuit with various Tuning Condensers. 0·00025 Mfds. Min	0·00025 Mfds. Max	0·0005 Mfds. Min.	0·0005 Mfds. Max	0·00075 Mfds. Min	0·00075 Mfds. Max	0·001 Mfds. Min	0·001 Mfds. Max
Igranic—contd.	400	8,980	26	…	…	…	…	910 (Natural Wavelength)	2,005 (o·oo1 mfds)	…	4,085	…	…	…	5,720
	500	14,510	25	…	…	…	…	1,135	2,538	…	5,210	…	…	…	7,273
	600	20,110	25	…	…	…	…	1,337	2,970	…	6,122	…	…	…	8,545
	750	32,300	22	…	…	…	…	1,588	3,775	…	7,720	…	…	…	10,825
	1,000	59,740	22	…	…	…	…	2,160	5,080	…	10,450	…	…	…	14,725
	1,250	91,830	22	…	…	…	…	2,680	6,310	…	13,100	…	…	…	18,240
	1,500	136,400	21	…	…	…	…	3,190	7,635	…	15,900	…	…	…	22,210
Lissen	25	…	…	…	…	185 (Condenser ·001 mfds.)	350	…	…	…	…	…	…	100	325
	30	…	…	…	…	235	440	…	…	…	…	…	…	130	425
	35	…	…	…	…	285	530	…	…	…	…	…	…	160	490
	40	…	…	…	…	360	675	…	…	…	…	…	…	200	635
	50	…	…	…	…	480	850	…	…	…	…	…	…	250	800
	60	…	…	…	…	500	950	…	…	…	…	…	…	295	900
	75	…	…	…	…	600	1,300	…	…	…	…	…	…	360	1,100
	100	…	…	…	…	820	1,700	…	…	…	…	…	…	500	1,550
	150	…	…	…	…	965	2,300	…	…	…	…	…	…	700	2,150
	200	…	…	…	…	1,885	3,200	…	…	…	…	…	…	925	3,000
	250	…	…	…	…	2,300	3,800	…	…	…	…	…	…	1,100	3,600
	300	…	…	…	…	2,500	4,600	…	…	…	…	…	…	1,400	4,300
Tangent	25	…	…	…	…	250 (Natural Wavelength)	375	…	…	…	…	…	…	…	…
	35	…	…	…	…	330	500	…	…	…	…	…	…	…	…
	50	…	…	…	…	430	770	…	…	…	…	…	…	…	…
	75	…	…	…	…	660	1,000	…	…	…	…	…	…	…	…
	100	…	…	…	…	840	1,300	…	…	…	…	…	…	…	…
	150	…	…	…	…	1,100	1,875	…	…	…	…	…	…	…	…
	200	…	…	…	…	1,610	2,500	…	…	…	…	…	…	…	…
	250	…	…	…	…	2,000	3,250	…	…	…	…	…	…	…	…

INSTRUMENT WIRE DATA

Size S.W.G	Diameter Inch	Diameter mm	Approximate Turns to 1″ (Hand Winding) Enamelled	SSC	DSC	SCC	DCC	Yds. to 1 lb. (bare copper)	Resistance Eureka per 1000 yds.	Current Rating Eureka 100° F	Current Rating Eureka 200° F	Nearest American Size B. and S.
44	·0032	·0813	··	··	··	··	··	10,760	83,664	··	··	··
42	·0040	·1016	··	··	··	··	··	6,850	53,564	··	··	··
40	·0048	·1219	··	··	··	·	··	4,780	37,184	··	··	··
38	·0060	·1524	158	110	92	90	65	3,060	23,808	··	··	34
36	·0076	·1930	125	92	78	76	58	1,910	14,840	··	··	32
34	·0092	·2337	104	83	67	65	54	1,300	10,128	··	··	30 or 31
32	·0108	·2743	90	73	60	58	48	944	7,350	··	··	29
30	·0124	·3149	78	65	53	51	44	717	5,575	··	··	28
28	·0148	·3759	68	58	48	46	42	503	3,914	··	··	27
26	·018	·4572	54	48	42	40	37	340	2,645	··	··	25
24	·022	·5588	44	38	34	32	32	228	1,770	··	··	23
22	·028	·7112	37	34	28	26	26	140	1,093	1·09	1·9	21
20	·036	·9144	28	25	23	21	22	85	661·3	1·6	2·8	19
18	·048	1·219	23	20	19	17	18	48	371·8	2·4	4·3	17
16	·064	1·626	16	14	13	12	13	27	209·4	3·7	6·6	14
14	·080	2·032	12	11	11	10	10	17	133·9	5·25	9·25	12

WAVELENGTHS PRODUCED BY VARIOUS TUNING COILS AND CONDENSERS

Capacity of Condenser in Microfarads	Inductance of Coil in Microhenries.														
	1	2	5	10	20	50	120	250	800	2,000	5,000	12,000	25,000	80,000	200,000
0·0001	19	27	42	60	84	133	206	298	533	843	1,333	2,065	2,980	5,331	8,429
0·0002	27	38	60	84	119	188	292	421	754	1,192	1,885	2,920	4,214	7,539	11,920
0·0003	33	46	73	103	146	231	358	516	920	1,460	2,308	3,576	5,161	9,233	14,600
0·0005	42	60	94	133	188	298	426	666	1,192	1,885	2,980	4,617	6,663	11,920	18,850
0·0007	50	71	112	158	223	353	546	789	1,410	2,230	3,526	5,462	7,885	14,100	22,300
0·001	60	84	133	188	267	421	653	942	1,686	2,665	4,214	6,529	9,423	16,860	26,650
0·0015	73	103	163	231	226	516	800	1,154	2,065	3,264	5,161	7,996	11,540	20,650	32,640
0·002	84	119	188	267	377	598	923	1,333	2,384	3,770	5,960	9,230	13,330	23,840	37,770

EXAMPLE   *It is desired to know the approximate maximum wavelength which will be produced when a Burndept "300" coil is connected in a circuit which is tuned with a condenser having a maximum capacity of 0·0005 mfds*

The inductance of this coil is given as 4770 microhenries   Neglecting the self-capacity of the coil it will be seen that the 0·0005 mfds line in the above table intersects the nearest inductance value (5000 mhys) at 2980 metres.

COILS AND CONDENSERS REQUIRED TO PRODUCE A GIVEN WAVELENGTH

Wavelength.	Capacity × Inductance	Wavelength	Capacity × Inductance	Wavelength	Capacity × Inductance	Wavelength.	Capacity × Inductance.	Wavelength.	Capacity × Inductance.	Wavelength.	Capacity × Inductance.
100	0·00281	380	0·0406	920	0·238	1,680	0·794	3,100	2·70	5,000	7·04
110	0·00341	400	0·0450	960	0·259	1,720	0·833	3,200	2·88	5,100	7·32
120	0·00405	420	0·0496	1,000	0·281	1,760	0·872	3,300	3·07	5,200	7·61
130	0·00476	440	0·0545	1,040	0·305	1,800	0·912	3,400	3·26	5,300	7·91
140	0·00552	460	0·0596	1,080	0·328	1,840	0·953	3,500	3·45	5,400	8·21
150	0·00633	480	0·0649	1,120	0·353	1,880	0·995	3,600	3·65	5,500	8·51
160	0·00721	500	0·0704	1,160	0·379	1,920	1·037	3,700	3·85	5,600	8·83
170	0·00813	520	0·0761	1,200	0·405	1,960	1·080	3,800	4·06	5,700	9·15
180	0·00912	540	0·0821	1,240	0·433	2,000	1·13	3,900	4·28	5,800	9·48
190	0·01016	560	0·0883	1,280	0·461	2,100	1·24	4,000	4·50	5,900	9·81
200	0·0113	580	0·0947	1,320	0·490	2,200	1·36	4,100	4·73	6,000	10·13
220	0·0136	600	0·101	1,360	0·521	2,300	1·49	4,200	4·96	6,500	11·9
240	0·0162	640	0·115	1,400	0·552	2,400	1·62	4,300	5·20	7,000	13·8
260	0·0190	680	0·130	1,440	0·584	2,500	1·76	4,400	5·45	7,500	15·8
280	0·0221	720	0·146	1,480	0·617	2,600	1·90	4,500	5·70	8,000	18·0
300	0·0253	760	0·163	1,520	0·650	2,700	2·05	4,600	5·96	8,500	20·3
320	0·0288	800	0·180	1,560	0·685	2,800	2·21	4,700	6·22	9,000	22·8
340	0·0326	840	0·199	1,600	0·721	2,900	2·37	4,800	6·49	9,500	25·4
360	0·0365	880	0·218	1,640	0·757	3,000	2·53	4,900	6·76	10,000	28·1

EXAMPLE (1) *It is desired to find the maximum value of a tuning condenser that will produce a wavelength of 500 metres with an Igranic coil No. "100."*

This coil has an inductance of 517 microhenries. From the above table the number 0·0704 is found next to the required wavelength of 500 metres and this must be divided by 517 The approximate result is about 0·0001 mfds.

EXAMPLE (2) *The tuning condenser has a maximum value of 0·0005 mfds, and it is desired to ascertain the size of coil to tune a closed circuit to 2000 metres*

The number corresponding with a wavelength of 2000 metres is 1·13, and dividing this by 0·0005, the result is 2260. On referring to the inductance coil data it will be found that the coil possessing the nearest inductance value to 2260 microhenries is the Gambrell coil "E."

TYPES OF RECEIVING VALVES

Designation	Filament Volts	Filament Amps.	Normal Anode Volts	Voltage Magnification	Impedance Ohms
Marconi Osram R	4	0.67	50-100	7	23,000
,, R 4 B	3.8	0.65	50-70		Detector or L F
,, R 4 C	3.8	0.65	50-70		Lower impedance than R 4 B
,, R 5 V	5	0.68	40-80	9	20,000
,, V 24	5	0.75	24-30	6	25,000
,, Q	5	0.45	Rectifying 25 { Amplifyng 150-200	50	..
,, QX	5	0.75	Rectifying 25 { Amplifying 100	20	.
,, DER	1.8	0.4	30-50	6	35,000
,, DEV	1.275	0.2	20-50	6	25,000
,, DEQ	2.75	0.2	24	20	27,000
,, DE 3	3	0.06	30-80	6	20,000
,, DE 5	.	.	.		
,, DE 6	5	0.3	80-120	6	10,000
,, LS 1	6	1.5	400	11	Power Amplifier
,, LS 2	6	1.5	400	5	Low Impedance P A.
,, LS 3	4	0.65	70-100		L F Amplifier
,, LS 4	8	2.2	400		Power Amplifier
,, LS 5	4.5	0.8	150	6	6,250
,, LT 2	3.5	0.11	30-50		H F Amplifier
,, LT 3	1.8	0.11	30-50		H F detector, or L F
Ediswan R	4	0.65	40-80	7	37,000
,, AR	4	0.67	20-50	5	40,000
,, ARDE	1.8	0.3	20-50	10	40,000
,, ARO 6	3	0.06	20.50	10	45,000

Designation	Filament Volts	Filament Amps	Normal Anode Volts	Voltage Magnification.	Impedance Ohms
B.T.H R	4	0.65	40-80	6	24,000
,, R 4	4	0.65	30-80	8	25,000
,, B 4	6	0.25	35-100	6	6,500
,, B 5	3	0.06	40 H F 60-80	L F 75	20,000
Mullard ora	4	0.65	30-60	6	General purpose valve
,, RA	4	0.7	50-70		Detector or L F.
,, S 3	5-8	0.65	15-30		
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